Vol. 64, No. 4, Pages 25 - 40

January 25, 🌣

### Seismology

GPUS SILVIC SOME SET TRAYEL INEX AND STATION FORRECTIONS FOR P-WAYES AT ILLESSISTED DISTANCES

A. W. Deleocati (Department of Seclegical Sefectet, Marward interestity, Cambridge, Masserboselts 02138), and D. L. Anderson

Approximately 3300 thellow focus earthquates and 1000 sateric stations have been acad in a tiledy of p-wave traval-those and station residuals, including arisathal effects. The sweate were tested from a sational effects with the sweate were tested from a sational effects. The sweate were tested from a category translations are provided for 994 tested to sations. The shallow corrections to sational training and the station for the tested attent, and two too he came with appropriate phase thiffs. They subbit goosers tendicatency over broad geographic areast and, where coverage it dente, often since actual changes from one geological province to another. The comine 20 terms appear to be due to upper result and anisotropy and shay correlate with the tirsue direction in the cruet.

J. Copphys. Fes., Red. Faper 231666 J. Georbyn. Fun., Red, Paper 281666

6920 Sairair soutem DUAL-HAMEST SPECTRA OF FOUNTIES LARGE RANHOUAKES P.G. Silver (Coolingles) Research Division, Scrippe Institution of Oceanography, La Jolia, CA 92093),

T.V. Jerden
Total-moment execute Hy(v) = ||H|w|| |/vT, whose H is
Total-moment execute Hy(v) = ||H|w|| |/vT, whose H is quakes tecorded by the loternational Daployment of Accelerocaters (IDA) network using the smaller-moment retrieval carbod proposed by Silves and Jordan (1982), lar unth event we obtain cetimates of My averaged overthe ten disjunct, one-cillibers (shell intervals in the low-frequency basel -11 sky, typical IDA record sere from events with My 2 0.2 A (1 A = 10<sup>47</sup> dyns - cml yield tecorded by the Internetional Deplo in-frequency hand 1-11 six, typical 10st record sense from events with \$N\_2 0.7 A [1 A = 10<sup>17</sup> dyns cml yield standard errors on the 1-six eventspace that are generally into the 30°. Our miltiple-shad settlents of \$M\_2\$ are usually consistent with temperable single-band values found by other lovestigators. From the total-sensent spectra we derive the sero-frequency (scattle) meant \$M\_2\$ My(0) and the absentanterists course duration of the moment-wise temperal; sense it is a function of the moment-wise temperal; sense it is and used spatial-temperal careate of m estended sources, but settlelians with resilieris source generated sources, but settlelians with resilieris source generative indicate that the interpretation of Tx etricity to take set the interpretation of Tx etricity is taken of the sensed temperal assess of m estended sources, but settlelians with resilieris source generative indicate that the interpretation of Tx etricity is taken of the sensed temperal assess of Tx etricity is taken of the sensed temperal memory leads to very little arror. A plot of Tx equilierity shows the septical scaling curve at Kanasori sed first particulates? and some below (freat rarthquakes). Exceptes of the forces include all three desp-force seests sentyred hara, as well as the 1910 Gelushis and 1951 Facu-folius desp-force serthquakes, whose total-somen spectra are calculated from the accommentance activities of Gilbert and Oslevocaki (1951, As anample of the lation is the second collevons of the factor to have a relatively shellow spectra, contested that informed to have a relatively shellow spectra, and britis portion of the accession lithosphyse. There other large serthquakes—Tongs (6/23/11 Mr = 23 1 2A), that is informed to have allein a sense of equility expensions. There other large serthquakes—Tongs (6/23/11 Mr = 23 1 2A), that it is forced to have a relatively shellow spectra with the faulting larget values of Ty. The effective allein of hoth the Tongs and Kurti Lalanda events of distributions of hoth the Tongs a

The section of the se

BODU SOLABLE SOUTONS OF LARGE

SOURCE TIME AND ACALING RELATIONS OF LARGE EARTHQUAKAS
Manoyachi Furusoto (Osperiment of Earth Scissons Negoya Usiversity. Chikuse, Negoya 404, Jepoet and tokiro Nakanishi
Source (ime is a kiesmetic fewit parameter corresponding to the dureling of edumnic cource (ime feectice and is eccarately detarmised from phoses of jong-pariod surface seves. Source (imes are detarmined for 86 great and lerge esthageache during the last three dacedee. Staling relations emoca caseros times, calcele moments, and femil dimension or derived. Setmes moment in proportices to the cobe of source lime, and femil dimension Ir proportices to cource time. Source times for company of the cooke of cource time, source times for deep-metrochae are found to be longer theo those of cuch other types of annikoekse eciminglisacily longer that the ruplers time expected from a heakall model. saggeoting that there sately generally en introduciory steps of femiling aktoh precedes the saio stage of the ruplers propagation. (coorce lime, soeling salation, cource parameter)

J. Geophys. Ess., Red, Taper 281878 J. Geophym. Bem., Red, Paper 2018/5

6950 Seispic sources FOCAL MECHARISMS AND LOCATIONS OF MARTHQUARKS IN THE VICINITY OF THE 1875 PAYABLE THROUGH

9950 Selevic courses

FOCAL MCRAHISMA ANS LOCATIONS OF MARKEGRAKE IN

THE VICISITY OF THE 1975 KALAPARA RANTAGUARE
ATTEREDCK ZOMS 1970-18791 INVILORITIONS FOR TECTORIOS OF THE SOUTH FLAME OF FILLANDS POLICATION

131ANS OF SAMALI

N. S. Crosson (Gasphysine Frongree, Daiversity of
Washington. Seattle, Weshington 98195), S. F.

Rado Ula. Geological Survey, Cassade Volumn
Observatory, Vencouver, Mestington 98651 and Capphysias Frogram. University of Washington. Seartie, Washington \$3955)

The Sevember 29, 1975, Kalapana certhqosha of
magnitude 1:1 on the south fame of Silawae Volunno. Saveli, Teyraceute of ea jor rift tantouic
eveni. The centrelar resulted from movecat on
a marrly bosicontal family place, with the casastal
block couth of Silawae's aret rift acous woving
south-southreatward ap to secural maters. Wellsecorded cauthquebus not the samth flank of
Kilrans from 1970 to 1379 aers saniyand and fonel
wathouses datarxiand to obselve better underetassing of the details of scale flamk leadualne,
luniuded are a large number of centhquebae from
the officashesh sequence of the 1975 carthqueba,
hubited diya 3 to 5 to the seast of a depth of
abous 5-9 to depth. This distribution coincided
with a portion of the sith plane of the Kalapan
are the sith place of the sith place of the Kalapan
are the sith place of the consistent with the
south of the old cossin crost. Fonel weedenlaws
at a thing large control throughout this time
pariod, both before and after the 1975 events, and
otocally agree of the large per plungs at the time of the
kalapane seriquebae. Such a chaige is comelism
at this sous of Kilapan the time of the
kalapane seriquebae. Such a chaige is comelism.

All such at the large seriphocke. To other sejdeans of grassicory resulpsiteds, the sine of the
kalapane seriphocke. Such a chaige is comelismen.

All such at the large seriphocke. To other sejdeans of grassicory resulpsiteds, televice of t

Japingley Poper 221892

4970 Steucture of Min Crant and Upper Montle COCORP AND THY CONTINENTAL ORDER

Just Officer (Superiment of Geningical Sciences, Cor University, Libers, NY 148531, Fraductor Cook, and

Jank Olivor (hopertment of Geological Scientes, Corall University, thece, NY 148551, Yrodurick Coch, and larry Srows

This is a speculative paper as the continental crest end for francier of madaris entitle force. Solest at Finction practiting date from the Cocomp project, corpied with alian hinds and geophysical and posicial characterisms, suggests at the struct. For example, there is only parapectives at the struct. For example, there is only parapectives at the struct. For example, there is only parapectives at the struct. For example, there is only exact from the Cocomp and from the Cocomp and from the Cocomp and from the content of the last from the cocomp and the struct of the content of the struct of the struct of the struct of the cruet. As depth is greated and the struct of the cruet. Are the corresponding rocks intrusioned for horsels are two parapects of the cruet. Are the corresponding rocks intrusioned to the figure decreased the struct. There is evidence for longe-scale threatist and raleted factures that methanises the great is and raleted factures that methanises the great is and raleted factures that methanises the greating that roles the possibility that ever and coche at a structure of the Wilees system to sook insured and paraleted factures that methanises the greating that roles the possibility that ever and coche at the committee of the work of the work of the structure of the wilees are structured to patts of forces cocking to consequences. In some pieces the modern habe and prices of the Mobe an accomplete to be and any paralete of forces completed the season hald of costs may an amount of these these paraletes the season hald of costs may an amount of the structure. The season hald and consequences and continuent to the modern have a manual three for long periods with a vertery of possible to patts of forces costs and continuent and patts of forces on the season hald end of costs may an amount of the season hald end of costs may an amount of the season hald end of costs may be a made th

testoules). J. Cmophys: Res., Red, Paper 251808

cheered on seignis, seflection process.
J. Geophym. Res., Zed. Feber \$51807.

an Once in 100 vears. where afails and that always separates the same blood of rosks pay he a major herriar to farther progress undesetunding the sontinuous oceat. (Comissants) crust, anisais seflantion profiling, COCORF, continuous Indicative of the record-high December Lestrolaa).

J. Grophys. Res., Red., Paper ZRISOS

5999 Generat isoole logging 1

D. SITU STUDIES OF VELOCITY HE FRACTURED

CHYSTALLING BOCKS

D. Moos 10.8. Geological Servey, 345 Middleilaid

Read, Menic Yerk, CA. 94085 and Stanford

University!, H. O. Enhand

A stady of the affacts of escreeaple fractured

on P- and B-wave valocities has been academistic in

four sells drilled to granitic rock to deyth

between 0.5 and 1.2 km. The affact of escreeapis,

fracture 1s to decrease both Vp and Vp and

lorease Vpv. In wells with a relatively

low decelty of escreeapis fractures, the is-after

esicalty is similes to their of escreen, the is-after

esicalty is similes to their of escreen, the is-after

esicalty is similes to their of escreen, the is-after

esicalty and there is a clear correlation between

some with mannascopis fractures and enhantestly.

las velonities. To molle alib mesticae macro
scople feesiurs, the lo site velocity is lower

from that of lotaes samples woder yescence, and

there is a coveletion between the rate at which

is ellu velocity innersess with dapth and the

sets at which the estecty of laborascry samples

laterasese alth pressure. Differences is is alta

p-wave valualty between wells cannot be anylative

actually by differences in the degree of ecoroscyle

freeling in the same for fraquencies ragins

from 10 Ms. C. 20. Ms. Title suggests that the

macrotractures affact velocity similarly over a

kroad fraquescy range. Chesical elteration of

rook adjaces to macropoopic fractores appear is,

play an important role in reducing in fracture of

rook shipsing fractions of play an important role in reducing a fraction of

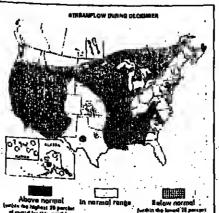
rook the velocity in a files in a selection profiles.

J. Ghophym less, Eacl, Rafter fails of reducing a fracture of

J. Ghophym less, Eacl, Rafter fails of reducing a filestory

descreed on eximals, es laction profiles.

In contrast to the many record high streamflows, key index gaging stations in parts of Kansas, Texas, South Carolina, Wisconsin, and a large area of southeastern New



turn of the century.

cial impacts that attracted Langbein's scientific attention. He wrote extensively on the subject, particularly after he transferred to Washington, D.C. in 1939. His technical papers, as well as those written for a more general audience, on the probabilities of floods and the relation of those prohabilities to social risks within the flood plains, and his book, Floods, coauthored with W. G. Hoyt, directly contributed to the development of a federal position on flood insurance. That position was implemented by the 1968 National Flood Insurance Act [P.L. 90-448: August 1,

During the late 1940's and early 1950's, Langbein was closely associated with the Soil and Moisoure Conservation Program of the Interior Department. He was particularly interested in the effects of grazing and land treatment on soil moisture and runoff, While associated with that program, he derised a 'tipping-bucket' rain gage recorder before recording rain gages became available. It was doring this time that he also became interested, through Earl Harbeck, in measuring evaporation and transpiration,

helow a reference mark—a task he later re-called as being his 'introduction' to hydrolo-

gy. In 1935, Langbein left the Rosoff Construction Company to take a position with USCS in Albany, New York. He had enjoyed his work with Rosoff and felt he had learned moch, although he never understood why Arthur H. Diantant, vice-president of the company, kept urging him to learn about least squares'—especially since none of the work called for such knowledge.

He began his hydrologic career in the theutraditional manner: by stream gaging and making slope-area measurements of Hoods. The professional atmosphere of the work in Albany made a lasting impression on Langbein: There was no time clock to punch, aitention was paid to details, responsibilities were delegated, and one was encouraged to learn. Throughout his career, Langbein sought to provide this atmosphere for others.

It was the hydrology of floods and their so-

Langbein recognized that the ranoff from drainage basins and the drawdown of aquifers could not be explained strictly in terms of climatic factors: an account of land use was no less important. To provide a rational basis for quantitatively accounting for land use, he collaborated with Luna B. Leopold in studying the carrying capacities of drainage basins in terms of their geomorphologic features. Together, they gave the first statistical expla-nations of R. E. Horton's 'laws' of stream orders and of the meandering of rivers. Whatever else might be said about this work |carried out in the early 1960's), it gave meaning to hydrology on a large regional and tempo-ral scale. A closer look at this work would do much to further dispell the notion that 'each river is a law into itself,' a notion that can be traced in the hydrologic literature back to the

From the time he recorded his first 'hydrologic' measurements while working on the construction of the New York City subway system, he never lost interest in matters pertaining to the collection of hydrologic rlata. lu fact, his interest in data collection increased as a younger generation was intro-duced to hydrology through computer simu-lation rather than through the gaging of streams and wells. He did not question the merit of this newer introduction, but he was concerned that the quality of the data not de-

His hook, Water Facts for the Nation's Fixure, coanthored with W. G. Hoyt in 1959, drew attention to how important systematic collec-tion of data is to development of water re-source systems. The book was the motivation for a comprehensive approach to data collection, now generally referred to as network design, in explicit terms of the economic worth of data. Following the Ottawa meeting of the International Association of Hydrologic Sciences in 1960, network design became of prime interest in hydrologic research in addressing questions about the relative importance of parameter estimation and choice of model in describing the stochastic properties of hydrologic processes.

Together with Luna B. Leopold and Ray Nace, he was instrumental in laying the foundation for the International Hydrologic Decade (1965-1975). His active participation did much to assure the success of the 'program' in furthering international exchange in hydrologic research, lu promoting a more structured approach to national data collection programs through network design, and in providing a more comprehensive description of the global water balance.

In recognition of his scientific contributions he was the recipient of many awards, among them the Bowie Medal (1969) and the Horton Medal (1976) from the American Geophysical Union, the J. C. Stevens Award (1963, with Thomas Maddock, Jr.) from the American Society of Civil Engineers, the Distinguished Service Award (1959) from the Department of the Interior, and the Warren Prize (1976) from the National Academy of Sciences. A year after he retired in 1969, he was elected a member of the Academy. And in November 1982, he and Professor Korzum of the Soviet Union were the corecipients of the International Prize in Hydrology for 1982, awarded by the International Associa-tion of Hydrological Sciences.

Many of us have lost a friend and colleague, one who so often and willingly gave us his technical help and wise counsel. He learned and then taught as much about least squares. We will miss him. Younger generanous will make his acquaintance, for his place in the annuals of hydrology is secure.

In his homer, a memorial fund for the study of water resources has been established at Couper Union.

This obitionry was written by Nick Matalon, a hydrologist in the Water Resources Division of the U.S. Geological Survey in Reston, Vn. He wither to express his appreciation for material on Langbein't early work which was provided by Row Laughein and Charles C. McDonald. (Photograph courtesy of the U.S. Geological Survey.)

# Yews

## Wet December for **Nation's Streams**

Walter B. Langbein:

1907-1982

Walter B. Langbein was born in Newark. New Jersey, on October 17, 1907, and died at

his home in Arlington, Virginia, on Decem-

ber 10, 1982. For 33 years lie carried on a

distinguished career in hydrologic research

with the U.S. Geological Survey-very much

Langbein graduated from Cooper Union in 1981 with a bachelor's degree in civil engi-

ning, he worked for the Rosolf Construction

Company, beginning as a rodman on a surveying team. At that time the company was

engaged by the city of New York in enlarge

Street and 124th Street, excavation was sus-

cause difficulties were encountered in lower-

ing the groundwater levels with promps. As

Langbein was given the task of measuring

the junior member of the engineering stall,

and recording the distance of the water level

pended a short time after it was begun be-

the subway along 8th Avenue. Between 128td

neering. While attending classes in the eve-

in the public interest.

Much of the nation experienced a very wet December, with 60% of the key index gaging stations in parts of 23 states reporting libers within the highest 25% of record, and record high December flows were set no key index stations in at least 14 states, according to the

U.S. Geological Survey.
As a further indication of the wet Decemher conditions, USGS hydrologists said that the combined flow of the nation's 'llig Fire' rivers (Mississippi, St. Lawrence, Columbia, Olio, and Missouri), which was boosted by runoff from rain-swollen streams, ended the year on a ivet note, averaging 1203 billion gallons a day (bgd) during December, almost twice the average for the mouth and the sercuth straight mouth that thus have been

above average. The intense flooding that affected much of the Mississippi and Missouri river basins boosted streamflow on those rivers to their highest December flows in 55 years of record. Flow of the Missouri River at Hermann, Mo., averaged 117 bgd, 347% above average for December. On the Misslssippi River near Vickburg, Miss., December flow averaged

741 bgd, 142% above average. In the areas heaviest lift by the flooding, streamflow runoff at many sites set new record highs and the recurrence lutervals of flooding in parts of Arkansas, Illinois, Louisiana, and Missouri exceeded 100 years. This means that on the long-term average, a flood of this magnitude is not expected to occur

discharge in the Midwest was the flow of the Mississippi River at Keokuk, Iowa, which averaged 81.2 bgd during December, the high-est December average flow in more than 100 years of continuous records at that site.



### York reported well-below average stream-flow—within the lowest 25% of record. Also in the East, streamflow conditions in the Delaware Rirer basin remain extremely low and drought covergency measures are continuing, Reservoir levels in the basin are still only about 39% of their full capacity.

The Swiss National Science Foundation (SNSF) annually awards a few international pustdoctoral fellowships for American scienlists involved in earth, astronomical, atmosplienc, mailtennatical, physical, or engineering sciences to work in Switzerland. Recipients must be under 36 years of age at the beginning of the fellowship tenure.

Swiss NSF

**Fellowships** 

Applications for fellowships that begin between September 1, 1983, and April 1, 1984. must be completed and returned to the U.S. National Science Foundation (NSF) by February 28, 1983. NSF will then transmit the ap-plications to the Swiss National Science Foundation. Awards usually are announced by

SNSF in July.
For application forms and additional information, contact Warren Thompson, Division of International Programs, National Science Foundation, 1800 G Street, N.W., Washing-

ton, DC 20580 (telephone: 202-387-9700). Subject to availability of funds, a few fel-lowships will also be awarded for tenure beginning between September 1, 1984, and April 1, 1988. Selection procedures are likely to change, however. Interested persona should contact NSF. Applications for the fellowships will be due at NSF by October 3,

# Radio Science Special Issue

A special issue of Radio Science will focus on the topic 'Emissions from particle beams in space. The scope of the issue will include emissions resulting from both natural and ardificial particle beams. Thus topics will include most emissions from planetary magnetosplieres as well as from controlled spaceborne experiments auch as those performed on the STS-3 shuttle mission.

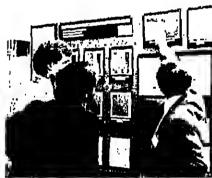
The deadline for recelpt of papers is March 1, 1983.

Submit papers to Erwin Schmerling, Guest Editor, STAR Laboratory/SEL Department of Electrical Engineering, Stanford University, Stanford, CA 94305.

# <u>Meetings</u>

# 1982 AGU Fall and ASLO Winter **Meeting Report**







Poster sessions, a growing part of the AGU meetings, are an attractive way for scientists to display

There were more than 2400 papers presented, with more than 3250 attendees registered at the 1982 Fall Meeting in San Francisco. This was the largest AGU meeting ever. Changes to the program and additional, late and revised abstracts are printed below.

### Papers Not Presented

A11A-14, R. L. Gardner et al.; A11A-1S, J. W. Erler et al.; A31A-01, W. H. Pollock et al.; G32A-06, P. F. MacDoran; G32A-11, F. Mulargia et al.; GP52A-02; B. G. Thompson; GP82A:01, J. Helgason; H12A-03, L. Duck-stein; H21A-17, D. R. Wiesnet et al.; H31A-03, D. H, Burn; H41B-04, D. C. Wilkin; H51A-08, G. Padmanabhan; H51A-09, K. L. Verdin.

Verdin.
LO11A-18, G. T. Taylor; LO11B-08, D. W. Krempln; LO11B-08, W. G. Harrison; LO12B-10, J. M. Morrell et al.; LO21A-12, A. V. Mendez; LO31B-02; D. Dogge; LO31B-14, J. R. Robertson; LO31C-02, D. Waslenchuk and R. Zajac; LO31C-03, M. C. Newman et al., LO31C-09, A. W. Herman; LO31C-10, P. R. Haberstrol and S. I. Ahmed; LOSIC-12, N. T. Sterman and B. B. Prezelin; LO31C-13, R. R. Cohen; LO31C-17, H. A. Vanderploeg; LO31C-22, G. L. Tagh-oon; LO42A-09, W. R. W. Li; LO52A-12,

A. W. Groeger et al.; LOS2A-11, R. L. Whit-

man; LO52A-12, A. W. Groeger. O11C-02, N. E. Huang et al.; O11C-13, F. Gonzalez; O11C-14, M. R. Mulheru; O12A-09, P. Ripa; O12C-02, R. W. MacDonald; O12D-08, D. Nof; O12D-14, P. F. Spain; O12D-15, H. Bryden; O12D-2), A. D. Kirwan et al.; 021A-06, C. Paola; O21C-04, R. H. Fillott; O21D-10, L. Magaard et al.; O21E-08, W. G. Granstein; O22B-06, J-Y Zlou; O22C-05, M. A. Kaminsky; O22D-05, L. Ladetran, O22D-18, R. C. Betarant. E. I. Lindstrom: O22D-12, R. G. Peterson; OS2C-11, F. S. Hotchkias; OS2C-16, C. Sancetta; O32C-19, J. C. Patterson et al.; O41B-07, C. S. Nelson; O41B-10, R. Iturriaga et al.; O41B-11, J. J. Simpson; O41B-15, R. C. Dug-dale and J. J. Maclanac; O51C-30, J. Condela; O52B-06, S. Honjo; O12D-05, E. A. Kelley. P31A-10, A. I. F. Stewart; P61A-6, F. C.

Michel; S32-01, J. Cipar and C. Market; SS2A-04, D. R. Hutchinson; S62A-09, R. Butler; \$72-11, J. A. Canas; \$81B-09, P. Scott; \$82A-08, J. R. Bowman; \$82B-08, R. A. Davis and F. J. Mauk; SA12A-02, A. Dasgupta; SA21A-02, L. M. Duncan; SM12A-13, K. Bruning; SM12B-08, K. Wilhelm; SM32B-15, .M. El-Raey; SM41A-02, S. Messick; SM41A-09, H. A. Garcia; SM51-07, H.M. Chang:-SS41A-09, H. H. Sargent III.,

Meetings (cont. on p.44)

The Oceanography Report
The focal point for physical, cheaical, geological, and bio-

Associate Editor: Assold L. Gordon, Lament-Dohenty Geological Observatory, Pallaades, New York, 10964 Helephone 914/359-2000, ext. 325]

# The Manganese Nodule Program

Michael L. Bender

Introduction

The Manganese Noclule Program (MANOP) began in 1977 with funding from the International Decade of Ocean Exploration (IDOE). It replaced an earlier IDOE ntogram that was started in 1972 in part by Maurice Ewing, MANOP's view is that the composition and occurrence of nodules can he best sindersmood in the context of the large variations in the rain rate of organic matter to the sleep-sea floor and the variable sedimentary geochemistry of their environment Therefore, from the heginning wuch of MANOP's sellore has been directed toward understanding the cycling of the biologically active elements-O2, C, nutrients, and trace metals—in the deep sea; in fact, this aspect

has itself become a primary goal of our work.

MANOP is studying manganese nodules and alwasal geochemistry at live varied North Pacific sites (Figure 1). The sites, in order of decreasing biological productivity in surface water, use site II, a freenipelagic sediment vite in the Panama Basin: sire M. a metallilerous sediment sice on 400,000 year old crust on the eastern side of the East Pacific Rise; site C, a calcareous ooze site at 1°N, underneath the equatorial upwelling zone; site S, a siliceous rioze site, that is nearly a site of nondeposition, with a ~1 in thick cap of Quaternary aluminosilicate sediment overlying Miocene siliceous oozes; and site R, a red clay site nonh of Hawaii. Manganese nodules are

present on the seafloor at sites H, S, and R.
The scope of MANOP is shown in the cartoun in Figure 2. The effost deroted to understand the cycling of bioactive elements includes determining the particulate flux to the seafloor, the benthic flux of dissolved chemicals across the sediment-water interface, and the burial rates of the bioactire elements. As part of this wosk, J. Dymond (Oregon State University) and A. Soutar (Scripps Institution of Oceanography) are deploying sediment isaparrays at each of the MANOP sites. The arrays are deployed for a year; and four trimonthly samples are collected from each trap so that seasonality in the particulate fluxes may be studied. Dyntond is analyzing C, CaCO<sub>3</sub>, Si, major elements, and trace metals in trap samples. W. Moore is analyzing U-series radinishtopes to study trapping efficiency and scavenging rates of these elements. J. Ed-mond (MIT) is studying cleep water hydrog-

raphy and distributions of trace nietals at our sites. S. Emerson [University of Washington), and M. Bender and D. Heggie [University of Rhode Island) are studying pore water chemistry to understand the rates and mechanisms of organic matter oxidation on the seafloor and the compositions of pore fluids from which nodule bottoms may grow. The rates of sediment accumulation at each site are being determined by T.-L. Ku [University of

outliern California) and D. Kadko (U.S.G.S., Menlo Park) using U-series dating. Rates of sediment bioturbation are being estimated by Ku and Kadko using Pb<sup>210</sup> and by K. Cochran (Woods Hole Oceanographic Institution) ising Th<sup>234</sup> and Pu.

Detailed studies of the marine geology are being done at each of the sites. Each site has been surreyed by Deep Tow 1F. Spiess and P. Lousdale, Scripps) for detailed bathymetry, bottom photography, bottom reflectance, and subbottom reflectors. The bottom reflectance studies, done with side-scan sonar, are particularly interesting, as they give a qualitative picture of nodule abundance variations on the seaftoor. At sites S and H, W. Gardner and L. Sullivan (Lamont) have taken bottom pliutographs over a yeor-long period. At H, we pliotographed and surveyed the sealloor with Ahsin in 1981. At all sites, R. Heath and M. Lyle (Oregon State University) have extensirely studied the major and trace element romposition of the sediments.

Studies of manganese nodules are ainted at understanding their growth rates and metal geochemistries. Dymond has studied the rompositions of whole nodules as well as scrapngs from tops and bottoms. P. Buseck and S. Turner (Arizona State University) are collaborating with MANOP, doing TEM studies of the crystallography of nodule minerals, Moore (University of South Carolina) and Ku hare made detailed studies of the uptake of U-series radioisotopes by nodules from seawater, pore water, and sediments. The most extensive effort has gone intu determining growth rates of manganese nodules by Th<sup>230</sup> clating, Pa<sup>231</sup> clating, and Be<sup>10</sup> dating like latter by T.-L. Kii of the University of Southern

times during the rourse of the experiments.

At the end of an experiment, scoops under

Two inaugural experiments are planned

sediment-water interface will be determined

experiments, radio-labeled metals are added

is subsequently determined in the chamber

water (as a function of time) and in the sedi-

about adsorption of trace metals by sediments

and nodules, of bioturbation, and of irriga-

menus and pore water (as a function of

depth). The results will give information

Fig. 1. Location of MANOP study sites IM = metalliferous, H = hemipelagic, C = cal-

for the Lander: benthic flux measurements

the boxes close and cores are thereby re-

California and E. Nelson of Simon Fraser The MANOP Bottom Lander, our largest single effort, is being constructed by R. Weiss (Scripps) 10 carry out in situ seafloor experiments hearing on many of the above areas. The Lander is a free vehicle with three box cores; it is designed for seafloor deployments of several months' duration, during which time microprocessor-controlled experiments may be run. During the deployments, turbulence within the boxes is maintained by circulating pumps of a new design, which hare rery low power requirements. The water within each chamber can be sampled up to 20

genetic reactions in sediments (Table 1), and radiotracer uptske experiments. In the benthic flux experiments, fluxes of O<sub>2</sub>, nutrients, C, alkalinity, and trace metals across the ganic N), a NO<sub>3</sub> decrease (reflecting NO<sub>3</sub> from the rates of change of concentrations in eduction), an Fc++ increase [reflecting the chamber water. In the radiotracer uptake to the chamber, and the distribution of spikes other reactions are also occurring: Mu+ must be oxidized by O<sub>2</sub> where it goes to zero, and Fe<sup>++</sup> must be oxidized by O<sub>2</sub>, NO<sub>3</sub><sup>-</sup>, or MnO2 where it goes to zero.

Organic Carbon Balance at MANOP Site H

Primary production Flux to the seafloor Oxidized by O2 Oxidized by NO3 Oxidized by MnO2 Buried below 40 cm

Units: µmol cm-2 yr-1

MANOP Site H Results: Deep Water Cycling of Bioactive

Rather than try to corer our entire elfort, this report will focus on the work at site II. MANOP's most studied station. A brief comparison of results at uther sites will follow.

This discussion of site II will start where MANOP started, with the Deep Torc work (Figure 3). The bottom shoals from a depth of \$650 m in the south to 3575 m in the north. The generally smonth rise is interrupted by a series of holes up to about 125 m deep near the center of the surrey area. Nodule cover, based on Deep Tow plintographs, decreases from about 12% of the sealloor in the south to 3-4% in the north. This smutth decrease is punctuated by the bare patches, remarkable areas up to 500 m wide from which manganese nodules are absent. The existence of these features was detected by the rontrast between the intensity of side scan sonar reflections from nodule covered seafloor and bare patches; it has been confirmed by Deep Tow photography and DSRV Alexa observations. The bare patches lie in the center of 2-3 ni depressions but are not clearly distinguished from nodule-rovered sediment by either sediment chemistry or pore water composition. At this point the origin of bare patches remains an important mystery.

MANOP site H underlies highly productive surface waters; therefore, we were not surprised when our Ahan work revealed that site H is an area of intense benthic biological actirity. Anemones, brittle stars, strimp, holothurians, echinoderms, and other animals are common on the seafloor. The site is crisscrossed with tracks, and more extensive deposits of disturbed sediment are common. These include sediment mounds, 'clettas,' and the fairy rings-moats about 0.5 m in diameter, with nodules in moats showing clear evidence of morement by organisms.

There is sume evidence that this high mganic matter flux drives rapid bioturbation of the sediments. Bioturbation rates of 500-1000 cm2/103 yr (15-30 times typical pelagic ralies) were measured in one cure by Huli and Ku from Th<sup>230</sup>, Pa<sup>231</sup>, and Pb<sup>210</sup> distributions. On the other hand, in another core, Pb210 gare a rate of 30 cm2/101 yr [Kadko, 1981), as was modeling by Heath of the distribution of solid phase diagenetic manganese probles lin which modeling transport of dissolved Mit through porc waters is balanced against transport of solid phase diagenetic

The rapid linx of organic matter to the seaffoor and its mixing into the sediments is reflected in the suboxic pore water chemistry at site H. Pore water chemistry may be frest understood in terms of the sequence of diawhich has been shown by MANOP and others to be universally followed [Froelich et nl., 1979). With increasing depth, pure water chemistry is characterized by a NO<sub>3</sub> increase (reflecting O2 reduction and uxidation of orreduction), a Mn++ increase (reflecting Mn()2 Fe<sub>2</sub>O<sub>3</sub> reduction), and a SO<sub>4</sub> decrease and an NH3 increase [reflecting SO4 reduction]. Two

In site H pore waters (Figure 4), the NO, increase, and O<sub>2</sub> consumption, are complete by about 1 cm depth. NO<sub>3</sub> reduction begins at about this depth and continues throughout

Rates of organic carbon oxidation in these reactions, calculated from diffusion reaction models, are given in the following table, along with the rain rate determined by sediment traps and the burial rate determined oduct of the organic C concentration and the sedimentation rate. At site H,

(11.6) (by difference)  $0.06 \pm$ 0.3

TABLE I. Reduction Reactions in Order of Decreasing Free Energy Yield

$O_1 + CH_2O \rightarrow CO_1 + H_2O$	Indicator
$2MnO_1 + CHO_2 + 4H^+ \rightarrow 2N_1 + 6CO_2 + 7H_2O_3$	NO <sub>3</sub> incresses NO <sub>3</sub> decreases
$2Fe_2O_3 + CH_2O + 8H^+ \rightarrow 2Mn^{++} + CO_2 + 3H_2O$ $SO_4^- + 2CH_2O \rightarrow 2CO_2 + S^- + 2H_2O$	Mn <sup>++</sup> increases.
Roy each in U.	NHs increases

For each reaction, the 'indicator' is the chemical whose pore water concentration change is most easily monitored. In O<sub>2</sub> reduction, NO<sub>3</sub> is produced by oxidation of organic N (not shown in the simplified strochiometry).



Fig. 2. MANOP cartions, showing project personnel and their rules.

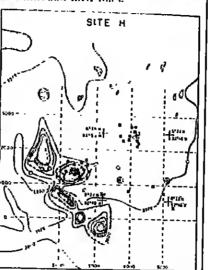


Fig. 3. Bathymetry and coring locations MANOP site H. Norlide corer increases fro ~4% in the mark to ~12% in the south. The ross-hatched areas are free of nodules. Boxes and circles represent coring sites.

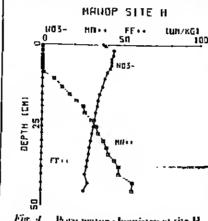


Fig. 4. Poor water obstaistry at site H. The changes occurring with depth reflect the equential reactions outlined in Table I.

about 2% of the organic carbon reaching the scallour is lurical to at least the depth of the core hottimis (--- II) cm). Similar amounts of arganic carbon are uxidized by NO<sub>3</sub> and MitO2. Nt)1 and MuO2 axidation rates yary by about a factor of 2 throughout the site. The results show that nearly all the organic matter reaching the scallant is axidized by Oz. The other exidants, while not important in regenerating organic C, nonetheless are crucial in mediating the amount of organic G (and notrients) ultimately removed from the system by burial.

As might be expected, diagonetic Mn remobilization has a major hillacuce on the distribution of sedimentary manganese (Figure 5). All cores have a surficial Mn rich znnc 10-20 cm thick, with solid phase Mn concentrations reaching 6%. Such a Mu-rich zone forms when Mn<sup>++</sup> released to pore waters by dis-genesis diffuses into the sedimentary mixed layer, is oxidatively precipitated, and is redistributed by bioturbation. It is noteworthy that the maximum in the solid phase Mn concerttration is sometimes well above the depth pore water Mn T goes to zero. 1111 feature suggests that some of the solid phase Mn profiles are not steady state features, bul relict from a time when the site was more reducing and Mn++ oxidation occurred closer to the interface.

### MANOP Site H Results: Nodule Compositions and Growth Rates

Huh and Ku have succeeded in radiometr cally dating one sile H nodule, measuring growth rate of 50 mm/m.y. for the top and 50 mm/m.y. for the bottom. The age for a nodule with a diameter of 8 cm would thus

of nodules underlying highly productive surface waters [Price and Cahvert, 1970], and result from the remobilization of Mn++ in sediments by organic matter axidation, as discussed earlier. How the nodule composition productivity relationship is mediated lowever, remains a mystery. At MANOP site H, manganese is reduced in the MnO2 ceduction zone, between 10 and 20 cm, and is oxidized and precipitated out at about 10 cm depth. Hence, Mn diffusion through the oxi-Fig. 5. Pore water [Mn++] (µM/kg) and dized zone to the sediment-water interface is solid phase [Mn] (weight %) in three cores

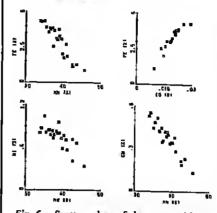
far slower than Mn incorporation into nodules (Table 2). This result shows clearly that nodules cannot grow from upward-diffusing diagenetic Ma\*\* if our pore water profiles are steady state features. Nevertheless, since the Mn+4 concentration rises by 5 orders of magnitude between bottom water and the MnO2 reduction zone, it is difficult to escape the conclusion that MnO2 reduction is some-

SCIE H PHOLE MODULES

m-37-80

0178 30-- 190/16 9 10 2 Fo 191, 21

a-95-80 1[#]



from MANOP site H. These slata record re-

duction of MirO2 at depth and upward diffe

sive transport of dissolved manganese, fol-

lowed by precipitation at 10-15 cm depth

and mixing to the surface by bioturbation.

Fig. 6. Scatter plots of the composition whole nodules at MANOP site H. High Mit nodules are enriched in sedimentary diagenetic manganese. This diagenetic manganese dilutes Cu and Ni.

be about 700,000 y. The growth sate is very rapid and undoubtedly reliects the supply of diagenetically remobilized Mn.

The Fe. Mn. Ni, Cu, and Co concentrations of whole manganese nodules at site H are summarized in scatter plots in Figure 6. The most striking feature of the composition is the high Mn/Fe ratio. It has long been recognized that high Mn/Fe ratios are characteristic

Send double-spaced manuscripts (four copies) to Est. AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above Editor: A. F. Spilliaus, Jr.; Associate Editors: Marcel Ackerman, Mary P. Anderson, Peter M

Bell (News), Kevin C. Burke, Bruce fine, Robert H. Eather (History), Arnold L. Goudon, Gerand Lachapelle, Christopher T. Russell; News Writ-eri Barbara T. Richman; Editor's Assistant: Kathryn L. Shupe; Eas Production Staffi Patricia Bungeri, Margarei W. Camelley, Eric Gurrison, James Hebblerhwaite, Dae Stong Kim, Vivian Nelson, Michael Schwartz.

Officers of the Union Olicers of the Union James A. Van Allen, President; Charles L. Orake, President-Elect; Leslie H. Meredith, General Secretary; Carl Klaslinger, Foreign Sec-retary; A. F. Spilhaus, Jr., Executive Hirector; Waldo E. Smith, Executive Director Emerius.

Advertising shat meets AGU standards is accepted. Contact Robin E. Little, advertising coordinator, 202-162-6903.

Ens. Transactions, American Geophysical Union (ISSN 0096-8941) is published weekly by the American Geophysical Union (1000 Florida Avenue, N.W., Washington, O.C. 20009. Subscription poice to members is included in annual dues [\$20.00 per year). Information on institutional subscriptions is available on request. This issue \$5.00. Second-class postage paid at Washington D.C., and at additional malling offices.

Copyright 1983 by she American Geophysical Onion. Material published in the issue may be photocopled by individual scientists for research or classroom use. Permission is also granted to use short quotes and figures and tables for publication in scientific books and journals. For permission for any other uses, contact AGU Publications Office, 2000 Florida Avenue, N.W., Washington, D.C. 2000. Washington, D.C. 20009.

Views expressed in this publication are those of the authors only and do not reflect official posi-tions of the American Geophysical Union unless espressly stated.

Cover. A nearly vertical fracture in the granodionte of Lake Edison, Sierra Neva-da, Galifornia, left-laterally offsets a mafic inclusion and an aplite dike by 8 cm. Structural data demonstrate that this small strike slip fault nucleated on a preexisting diational fracture (joint). Thus this frac-ture records two distinct deformational events: an extension followed by a left-lateral shear. Strike-slip foult zones with offsets of up to 100 m developed from simllat small faults. From, Nucleauon and growth of strike-slip faults in granite, by P. Segall and D. D. Pollard, J. Geophys. Res. 88, 555-568;

nodules under upwelling areas. But how is Mu supplied to such nodules if not by steady state upward diffusion? Several possible explanations may be invoked: First, the MnO<sub>2</sub> reduction zone may randomly migrate up and down in the sediment (perhaps in part due to the occasional creation of microenvironments) and, at cer-tain times, lie shallow enough to supply Mn to the interface. Perhaps, for example, the MnO2 reduction zone migrates in response to long time period changes in the forcing func-tions, such as a change in the sedimentation rate associated with glacial periods. Another explanation is that the depth of Mn++ oxida tion may be fixed at about 10 cm, and manganese nodules may be placed at this depth for short internals by hioturhation, either as a result of being pushed down by animals or being covered temporarily by sediment mounds. Today, about 5% of the manganese

how responsible for the high Mn/Fe ratios of

nodules are at the Mn \*\* oxidation depth. We do not know if these nodules are in a short active growth phase or are simply en route to being buried. A third possibility is that the nodule Mn may derive from solid phase oxidized or reduced Mn (e.g., MnCO<sub>3</sub>) brought into the Mn-rich zone by (emobilization. This Mrt would be transported from the depth of Mn\*\* oxidation (about 10 cm) to the sediment water interface by biorurbation, This hypothesis gains plausibility from the recent paper by Pedersen and Price [1982] showing a high level of reduced Mn in solid

Whatever the exact mechanism by which nodules incorporate remobilized Mn, its oc-currence has a simple and dramatic effect on module composition (Figure 6). Dymond has shown that compositions of whole site H notules reflect mixing of two end members, a nodule bottom end member incorporating Mn remobilized by MnO2 reduction and a nodule top end member precipitating from seawater and thought to derive from oxidative diagenesis. The anticorrelation between Mn and Fc in these figures is dictated by simple mass balance but the linear mixing lines for Ni versus Mn, Cu versus Mn, and Co rersus Fe can be explained only as end member mixing. The positive rovariation of Co with Fe is expected, since Co is present in an ironrich phase; however the anticorrelation between Mit and Ni and Mn and Cu is the opposite of that observed in most pelagic not ules. Cu and Ni in site H noclules are likely found in a Mn-rich mineral; the very low concentrations of these metals in nodule bottonts probably reflects a swamping of pore water Cu and Ni by diagenetic Mn and exclusion from nodules because of their low con-

centrations relative to Mn ln pore waters. Summarizing our site H results, our detailed studies show that the seafloor at site H has the characteristics which one might expect for a relatively shallow abyssal site un-derlying high productivity surface waters. A high rain rate of organic matter sustains a vigorous benthic macrofaunal community and rapid organic matter degradation with the sediments. Nearly all organic matter falling to the seafloor is degraded by O2 oxidation; oxidation by MnO2 and NO5 contributes negligibly to regeneration but is imporhuried and ultimately removed from the system. Sediments are influenced in a number of ways by organic matter degradation, most noticeably by manganese recycling. MnO<sub>2</sub> reduction also supplies manganese to the nodulea and leads to very high growth rates, although we are unable to single out the diagenetic Mn transport mechanism. The extensive incorporation of diagenetic manganese into nodules is reflected by the rapid growth rate and high Mn/Fe ratio of site H nodules and the difference between top and bottom chem-

TABLE 2. Growth Rates of Nodules at the MANOP Sites and a Comparison of Manganese Accumuladon Rates in Nodules With the Flux of Diagenetic Manganese Through Pore Waters to the Sediment-Water Interface

Growth rate (mm/ m.y.)		Mn accumu- lation rate, moles cm <sup>-2</sup>	Diffusive Diagenetic Flux, moles cm <sup>-2</sup> yr <sup>-1</sup>	
R	0.6-3		3 4 .	
S	5	3 × 10 <sup>-9</sup>	0.01 × 10 <sup>-9</sup> ≤2 × 10 <sup>-9</sup>	
H	50	70 × 10 <sup>-9</sup>	≲2 × 10 <sup>-9</sup>	

istry. The top-bottom contrast dominates nodule composition at site H: nodule composition can mostly be explained in terms of mixing two well-defined end members of

# Comparison of Results at Other

MANOP has retrieved seasonal sediment traps from M and H and annual traps from M, H, and S. Annual near-bottoin total particulate fluxes at M and H are similar; at S the value is about a factor of 5 lower (Table

TABLE 3. Summary of Organic C Fluxes at MANOP sites M, H, C, and S

	Site				
	М	Н	С	s	
Flux to scallpor Oxidized by	12	15		1.8	
O <sub>2</sub> NO <sub>3</sub> -	(10.2)	(10.6) 0.08	19 0.08	1.6	
MnO <sub>2</sub> Fe <sub>2</sub> O <sub>1</sub>	0.15 0.014	0.06	0.01		
SO <sub>4</sub>	0.15		2.3		
Buried below 40 cm	0.4	0.2	0.2	0.0	

Among these four sites, pure water chemistry changes such that pore water profiles are progressively stretched out as organic matter rain rates fall [Figure 7]. That is to say, as the flux of organic matter reaching the seafloor decreases, zones in which the rarious oxidants are consumed occur deeper within the sediments. Only when comparing sites M and H does this generalization fail. Fluxes to the seaffnor are similar at these two sites, but the redox zones are much closer to the sediment surface at M. The sites differ in that M has a higher sedimentation rate, while nodules are present at H. More intense diagenesis at M may reflect more burial of organic matter due to the faster sedimentation rate leag. Midler and Suco, 1979]. Alternatively, it might be that more organic matter is oxidized before burial at 11 because nodules allow a more vigoraus benefic community to exist; if so, nodules must have a major and heretofare misuspected impact on sediment geo-

The solid phase Mn distributions at M. H. C, and S are similar to what is expected from the jure water Mn\*\* gradients discussed earlier. At M and H, the depths of pore water Mu\*\* axidation are within the sedimentary mixed zones, and there accordingly are MisO2-tich bands tien the sediment-water interface. The depth of MnO2 reduction is closer to the interlace at M, and the Mn-rich laycr is thinner. At C, Mn++ oxidation occurs at about 20 cm depth, probably just below the mixed layer. The solid Mn distribution is thus characterized by a discrete Mn-rich layer centered at the depth of Mn ++ oxidation. At S. where there is no pore water evidence for MnO2 reduction, and at R, where pore waters are also assumed to be oxidizing, there is nevertheless a sediment surface zone in which Mn is slightly enriched. The origin of this

Key features of nodule romposition at sites H, S, and R are summarized in Figure 8, and growth rate data is given in Table 2. The most striking result is the high growth rate and Mn/Fe ratio at site H compared with the other two sites; these features reflect the supply of diagenetic Mn from the underlying sediment. It is more difficult to understa why, if there is no MnO<sub>2</sub> reduction at site S, the Mn/Fe ratio of site S nodules is higher than that at R. Dymond has argued that metals in site R nodules are primarily hydrogenous; that is, they are derived from precipitation out of seawater. Site S nodules are ought to have a diagenetic Mn component that derives not from MnO2 reduction but from Mn released from sedimentary ferromanganese hydroxyoxides when Fe reacts with biogenic SiO<sub>2</sub> to form nontronite [Lyle et al., 1977]. Since both R and S nodule bottoms are richer in manganese than tops, the hy-drogenous and oxidative diagenetic compo nenti are thought to supply metals at both sites, with the oxidative diagenede component being greater at S.

At site S, the upward manganese flux at the interface, calculated from the pore water concentration gradient, is 3 orders of magnitude less than the rate at which manganese is assimilated into growing nodules. Therefore, another source of manganese is required, and this is believed to be solid Mn released very close to notfule surfaces as a result of tise oxidative diagenesis reactions discussed earlier.

Thus, while we confirm the increase in

nodule Mn/Fe ratios with increasing produclivity, our work supports the mech proposed by Lyle et al. [1977] and indicates that this relationship is mediated in ways very different from that envisioned by earlier workers. In ollgotrophic waters and upwelling boundary waters (as at sue S), productiviincreases nodule Mn/Fe not by providing lagenetic dissolved Mn++ but by providing SlO2, which sequesters Fe and releases Mn to nodules in an oxidative process. In higher roductivity waters, where the Mn++ oxidalion zone is close to the interface, incorporation of dissolved diagenetic Mn++ is poss)-

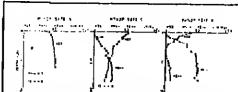
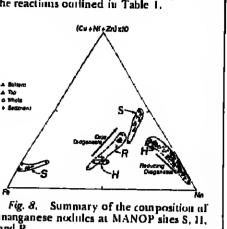


Fig. 7. Summary of pore water roucentrations of the redox indicators at MANOP sites S. C. and M. Again, chemical changes reflect



ble only if nonsteady state conditions are inroked, if we assume sseady state and growth of module buttoms at the interface, the very high Mn/Fe ratios of middle bossoms at site H must be slee to insorphration of solid diagenetic Ma mixed up by biotsrbation from the Mn<sup>++</sup> exidation zone.

It has been widely demonstrated that, among pelagic modules, Cu, Ni, and Zu concentrations increase with increasing manganese. At sixes S and R this relationship is fol-Inwed, buth when comparing whole audules from one site to another and when comparing tops and bottoms at the same site. At H the trend is reversed, for reasons sliseussed

In summary, sediment fluxes to the seatheir decrease in the same order as surface produstivities (M = H > 1; > S). As produstivity drops, redox zones in the pore waters ase spread sun to greater and greater depths. At the two high productivity sites, Mn is re-mobilized and oxidized within the sedimentaty mixed zone, forming a Mn-rich layer near and at the interface; at site C. Mn is remobilized and uxidized just below the mixed zone. forming a discrete Mn maximum, and at site S the MnO2 reduction zone is not penetrated

Nodule growth rates and Mn/Fe ratios increase with increasing organic matter flux to the seafmor. (Ni + Cu + Zn) increases with increasing Mn until productivity becomes very high, at which point the trace metals are drowned out by Mn and their concentrations in nodules drop.

### References

Froelich, P. N., G. P. Klinkhammer, M. L. Bender, N. A. Luedtke, G. R. Heath, D. Cullen, P. Dauphin, B. Harmann, and V. Maynard, Early oxidation of organic matter in pelagic sediments of the Eastern Equatorial Atlantic: Suboxic diagenesis, Geochim.

Cosmochim. Acta, 43, 1075-1090, 1979. Kadko, D. C., A detailed study of the uranium series nuclides for several sedimentary regimes of the Pacific, Ph.D. dissertation, Columbia Univ., New York, 1981.

Lyle, M., J. Dymond, and G. R. Heatk, Copper-nickel-enriched ferromanganese nodules and associated crusts from the Bauer Basin, northwest Nazca Plate, Earth Planet. Sci. Lett., 35, 55-64, 1977.

Muller, P. J., and E. Suess, Productivity, sedimentation rate, and sedimentary organic matter in the oceans. I, Organic carbon preservation, Deep Sea Res., 26A, 1347-1362, 1979.

Pedersen, T. F., and N. B. Price, The geochemistry of manganese carbonate in Pnnama Basin sediments, Geochim. Cosmochim. Acta, 46, 59-68, 1982,

Price, N. B., and S. E. Calvert, Compositional variation in Pacific Ocean ferromanganese nodules and its relassonship to sediment accumulation rates, Mar. Geol., 9, 145-171.

## News & Announcements

### Glomar Challenger Finds **Ophiolite**

Deep Sea Drilling Project (DSDP) hole 504B located in the eastern equatorial Pacific, 201 km south of the Costa Rica Rift (CRR), is unique in several ways. Hole 504B extends 1.35 km below the seafloor, which is at a depth of 3.46 km; it has penetrated selamic layers 2A; 2B, and part of 2C and for the: first time has provided a very complete section; and it has bottomed in what has been nterpreted as a true ophiolite complex. These results constitute for the first time long awaited confirmation of accepted models upon which most oceanic crust theory has.

A recent report of DSDP Hole 504B noted that '... one is led to question the validity of using ophiolite as models of ocean crust' (Nature, December 16, 1982). That statement was representative of the state of uncertainty that existed before the hote was drilled. The drill site is bicated nii magnetit anomaly 3', which has an age estimate of 6.2 m.y. The location, south of the CRR, lies on the easternmost arm of the Galapagos Spreading Center, ideally situated over uphiolite lithostratigraphy, il most current models of the oceanic crust are correct. Hesitation with the acceptance of these models has arisen in recent years from the rarity of dredgest and drillest rocks that can be positively identified as being samples of an ophiolite complex. Hole 504B, being along the southern flank of the CRR, should be a good test case.

What was expected to be encountered in the hole was a penetration of seismic layer I (pelagic seilments), then Iresh to altered basalt pillows and flores (seismic layer 2A). metamorphosed basalt pillows (seismic layer 2B), and finally selsmic layer 2C, the characteristic metamorphosed basaltic dike complex. The entire seismic loyer 2 is variable, but avcrages about 2.5 km in thickness. The underlying layer 3 is thought to rousist of gabbros and more or less serpentinized ultrantalic cumulate rocks of approximately 4.5 km thick-

Drilling of hole 504B on DSDP leg 83 was a continuation or re-entry of the hole that was started on legs 60 and 70. Leg 69 extended to a depth of 489 m, leg 70 to 838 m. With a few complexities, the lithostratgraphy turned out to be just about ideal. Basement rocks were encountered at about 275 m. For the next 575 in depth, pillow lavas, flows, and tectonic breccias were encountered. This pillow/flow sequence was underlain by a 209 m transition zone consisting of pillows and minor flows cut by dykes. At depths below 1055 m (BSF), nn more pillows were found; only a sheeted dyke complex characteristic of ophiolitic models of the oceanic crust was drilled to the bottom of the hole.

An extensive snite of geophysical measure-ments were made in addition to the collection of drill cutting samples. Down hole logs of sonic velocity and attenuation, X ray density. neutron porosity, and resistivity were obtained. A borchole televiewer was used to record fracturing and reflectivity. Thus, the study provided an excellent opportunity to compare geophysical depth data with petro-graphic analysis of the well samples.

Layer 1 contrasts in properties with those of the basement rocks in that the first 275 m of sediment at hole 504B are mostly siliceous naunafossil oozes, grading into chert at the

Seismic layers 2A and 2B correspond rath-

er well with the geophysical logs to the open-ly fractored and smeetite-filled fractured pillow-breccia-flow layers, respectively. The interval between 846 m and 1,055 m, designated petrographically as the layer 2B-2C transition zone between pillow/flow and dyke complex, was not so subtle in the representation of the geophysical logs. There was a relatively sharp transition, extending no more than about 50 m, as represented in the geophysical logs. A distinct layering, for example, was deduced from bulk porosities calculated from resistivities. The layering corresponds to the seismic layers 2A, 2B, and 2C, which is the lirst ubservation of a section through layer 2. The results of the DSDP

Hole 504B study confirm '... that the main features of the upper part of an idealized ophiolite sequence occurs in the oceanic crust' (Nature, December 16, 1982).-PMII

### **Expedition Invites** Research Opportunities

A Long Lines Expedition for Hydrographic stations will be made along the Greenwich meridian from 7°N to 35°S, with a part stup at Capetown, South Africa, then southward to Antarctica and westward through the Smitia Sea, ending at Punta Arenas, Chile. The work will begin in the fall of 1983 and linish early in 1984. Surface to bottom measurements of temperature, salinity, oxygen, and nutrients will be made at approximately 1111 km intervals. The purpose of the expedition is to collect data to study the general rirenta-tion of the eastern South Admitte Ocean, the Antarctic Circumpolar Current, the castern extension of the Weddell Gyre, the llow of deep water from the Weddell Sea that extends northward east of the South Sambwich Ridge, and the regional oceanography of the

The expedition offers an opportunity for measurements of such other characteristics (tritium, helium-3, freon, carbon dioxide, etc.) as can be accommodated aboard. Parties interested in carrying out such programs should call or write J. L. Reid at the Scripps Institution of Oceanography, La Jolia, Calif. (telephone: 619-452-2055) or W. D. Nowlin at Texas A&M University, College Station (telephone: 713-845-2947).

### U.S. Ocean Policy Under Law of Sea

How the United States' use id the ocean will be altered when the international law of the Sea near comes into place will be explured at the University of Rhade Island's (URI) Genter for Ocean Management Studies' (CCOMS) seventh annual conference, June 12-25, 1983. Significant imparts on U.S. mean inpress and policy of the United States' decision not to sign the worbleide convention will be examined in obtail.

Among the topics to be discussed are the international political context of the negotiations and the P.S. position as it changed from support to opposition; the costs and benefits of signing and not signing the treats the status of monscalled provisions as customare international law; special problems and apportunities of scaled mining and navigation; and suggestions for Intere U.S. strategies. The Law of the Sea Treaty (Ens. June L. 1982, p. 523) was formally signed recently by almost 120 nations; two dozen countries, inchilling the United States, have refused to sign, laurever.

Lawrence Juda, chairman of the IJRI Departnernt of Geography and Marine Affairs, will chair the conference. John A. Kirauss, vice president for marine programs at URL is a member of the planning committee. He has served as an advisor to the Law of the Sea delegation. The conference will be held at the URI Narragansen Bay emujors.

For additional information, consect the Center for Ocean Management Studies, Kingsom, R1 02881 (telephone: 401-792-

### Meetings (cont. from p. 41)

T51A-07, J. J. Jaeger; T51B-08, A. Schedl; T52B-12, T. Matsui et al.; T61B-03, E. Bonatti and K. Crane; T628-01, P. L. Ward: T62B-05, K. Crane: T62B-08, L. Gamboa: T71B-09, C. H. Scholz; T71B-13, N. Warren; T81A-05, K. D. Gerdes and P. Styles; T81B-07, M. Wyss; T81C-02, H. A. Falver; T82A-13, L. Smith; f82C-10, J. F. Swenney.

V42A-03, H. Z. Lii and M. L. Crawford: V71C-00, G. A. McKay; V8IC-08, L. G. Medaris et al.; V81C-12, A. K. Baksi; V81C-14. P. J. Leier; V81C-24, W. H. Zuller et al.; V81C-25, D. L. Finnegan et al.; V81C-26, D. S. Ballentine et al.; V81C-27, J. M. Phelan and W. H. Zoller; V82B-04, G. T. Nixon.

### Late and Revised Abstracts

Atmospheric Sciences

Practicus in Contred Air

J.K. CRLES. S.C. PASSEMETM. W. VALUET, Y.A.J. YAR LINI INIAN DOS PROGRETTH CORPOR 3521 Ruftin Goad, San Olaga, CA Sfifi] [Sponsor: D. Gardner)

Difference between breakdown in ionized ein and breatdern in non-lonized ein haus been obserred. Retentit a
sodoi wits formvisied to espie bi the treation and gropasitios of abstrictal discourages in bosised ein. The
tirester growth rube ass determined by the rate of which
tourness flowing in landsed conductive air can value air
temperature as the lip of the streams to full thereal
textistion (KTML 87). To test inhis codal, se experient
textistion (KTML 87). To test inhis codal, se experient
textistion (KTML 87). To test inhis codal, se experient
textistion (KTML 87). To test inhis codal, se experient
textistion (KTML 87). To test inhis codal, se experient
textistion (KTML 87). To test inhis codal, se experient
textistion (KTML 87). Discound Laborator [storad
tistal linear First on the proposition of textistion
textistion of a captarte 100 SV pulser sovided the field
[storad years]. At least tive times given are created
which propagates 9 4.5 cm during ANDOMA 1818 or relation
to the textistion of textistion of rediction lines width, and quenched on capsation of rediction lines extended the control voltage
about the textistion of textistion and the current voltage
peristions is good serveyh to lead contiderable credibilitty to the theory.

An Apparent Scots Offerance between Doppler Stations and SEASAT Alticatry Geoids

3001 G. KIRK |Geodynamica Corp., 55 Hitthcock Way, Saile 209, Sania Barbavo, CA 91105)

Sould height values from NMALIZ coordinates at 310 coality Coppler stations having good ties to main tag level were to parad with the eceres 15' n 15' orld paint values in the NAVOCEANO SEASAT el tirretty good halphi dato set. A ream difference of 2.2 metart was obtained. A similar compavises of Doppler values with OSW SIASAT 1' a if mean good beight values results in a mean difference of 2.2 metart also. These mean difference were obtained of the recovery of Z-toordissis differences identified in various and uses now differences identified in vertous analyses and verified by the 2.3 cater origin offset between the ellipsoids which her lit the RAVXIANO and OSU quoids. These differences saggest that scale or other systematic outers in occoss of I rater fourint in goold determinations. Passiolo captarations lectude:

- Systematic near-shoro fide rodel, current, or meosisle errors,
   frogs in alfricoter collibration, ot its
- ininterestation,

  3. SEASAT orbit rodest priors,

  4. MMLSIZ State error,

future librit Persistion Gravicy and Assessa

For the jour 2 years MACA has been developing the concept of a geopoleant of research mission that that would assume the earth's provide and assument finish would assume the earth's provide and appeared finish with a remaint one of 100 he over the entire girls. Proposed for James bound the end of this dears the wission would come as of two spencerest to limit only possess could all institute the state which we attitude and appeared by a has hapdened killmenters. The end appeared by a has hapdened killmenters. The waster to forfire the earth's gravity anguestic and one of the state of

### Hydrology

The Payelope-key Technique and Chance Comptraint Programming

TERCOORS O. BORYS (Bursey of Reclamenties, 2500 Cottone Way, Sepremento, CA 55821

So napublishes mass-ourve type of analysis is consider with chance constraint programming consequents. Throughts insufing to this combination were stimulated by Eleman 1979 article, [/

The mann-ourse technique in question was developed by Sobert A. Williams. It has not own published. It is a technique which is senter to apply them the sechniques in the clied eritole. Combining it with chance comstraint occepis permits the dericoment at chance comstraint formulation which does not have some of the problems identified by Eleman. It should be recognised, however, that all much "made-ourse" lechniques rait on a treacherous tistion. The flation is that a perfect toresight operation policy is possible.

P fices "Signage time-Curra Sositati in a System inalytic Perspective," dater Assurance Research, tpris 1979, v 15, o 2.

Analog Tank Systems in the Development of Biomesay
Rethod Using Aufworks

O. V. SMITM (Sanitary Engineering and Entironmental Hatith Research Laboratory, Rithmond, CA 94804) J. C. ROTH (Sanitary Engineering and Entironmental Hatith Research Laboratory, Richmond, CA 94804) A. J. HORNE (Sanitary Engineering and Environmental Realth Research Laboratory, Richmond, CA 94804)

Aufwichs is a sonsitive, low cost fool that can ald regulators and dischargers in detarmining ellects of eusicipal and industriel wastematare as the blots of local receiving water. Effocts of bostlaulatory imunicipal end took it is is mighted industriel) discharges on gufmuchs grown on artificial substrates were samessed in 3000 t assing tanks, Perseniars considered incided 0.2 generation, 0. uptake, chlorophyll a and blowse. The method shows clear dillorences become vorious dilufter lavels simulating those encountered in San ironcisco 8ay. The results from that experiments have corroboreled results of simultengous flaid stadles which also showed blostleuistory affects varying with wastewater dilution rate.

American Society of Limnology and

Post-Specifing Plankton Communities of the Anchovy Specifing Environment

s. M. Cuen and A. Alvarino (MOAL/MMPS), ta Jolia, CA 92038] 4. Racht (UCSS, Santa Barbare, CA 93105)

he report on measurale spatial variation of Phytoplankton and small sooplankton corcentration and osspecities, and infer their besporal turistion in and beyond the anchory subject off Southern California. A variaty of silphosed and satalite observations in April 1951 clearly define the environment from which sample sets were drawn for summerations of small planktons we sampled a 200 km plume of sets strongly influenced by coastal upwalling of less than 2 weeks duration, a relief summer deter stronty introsected by community of iess than 2 weeks duration, a railog pluss i-2 mails old, and community with no algorithms of questing influence. Allocation of spanning affort in the area by the northern interred from the observed distribution of their eggs and larves. Very recent spashing stforf was restricted to the region inshore and south of the new plume and was highest mear the plume linits. Sallet plume and offshore occamio water were devoid of spashing

mear the plume limits. Relict plume and offabora oceanic water were devoid of spanning products.

Compare with ambient oceanic water, core water of the new plume was cooler by about 3 deg. C. more estime by 0.3 o/so, and rieber in chlorophyll by festors of 30-90. Mirrate, mitric, phosphate and slivests concentrations water slewated in the mixed layer of the new plume, the continuing plume, were generally greated in the new plume. Thus continuing local antichment of the photic layer is likely to have contributed to local surjohannit was the most diminished stability in the plume, water generally in likely to have contributed to local surjohannit was the most diminished stability in the plume, water season diminished stability in the plume water and the surface flow essociated with the super 100 s. Within plume limits, the destratification occurred within the sums of intensified surface flow essociated with the super limits and as sunds that the head alchordment plume and as sunds that the head alchordment plume and as sunds that the head alchordment in the super source of wortical value for intensified vertical sulfag. Sifects of line source usualling thus appear self-perpeffering wall downstress of the primary, upsailing, the response, settled volumes of plankton ware greater by factors of 1-70, and consisted of the formstress effects. In the plume was dominated by chair distors, as alley Schebocaros spp., and the mosphankton by Calanus pecifics.

Circulation in Sulsun Bay: Data and Humorical Model Analysis

ROY &. WALTEST JUSCS, Henio Forh, CA 98025) See level date and current meter data gathers in northern Sen Francisco Ony are analyzafi with respect to Lidel varietions iperions of one day or less! and low frequency variations ipercade of several Date and longer!. It this area is of importance in a chemical and blooksion; some, this snelysis attropts to lookily tas physical orcesses that are important to virculation and reseases that are important to circulation and lise. The Heal veriation compains the mitise. The line veriation beginstes the indestrations assets when it is a frequency vertations in sea level in Eulaun Ray are atrongly coupled to consist ass (avel in Eulaun Ray are atrongly coupled to consist ass (avel in Eulaun Ray are atrongly coupled to consist of material and effects, and the tides cause of material and its larger during coupling times that its larger during coping times that our ingress the lever in the larger during fraytations currents of aping a density of two for install mean flow, both of which very atrongly with the Spring-need tide of the levery atrongly with the Spring-need tide of the larger density on the sean tallouity lines the mean salinity line-mean advective component and not the correlation between tides variations in velocity and salinity (dispersive component). and salinity (dispersive component).

Two movential poles are used of increase universalist of the hymneles of Soloun Nayi ii a finite element iidol souel lased upon the smallow water equalions which computes inc amplicular and phases of the various tials ispecies and reproduced (no especial features of the cides, and "i a residual circulation model isfuleriant which is residual circulation model isfuleriant which is currently two dimensional floorization and requires the addition of various variations to reproduce the dynamics inferred translational analysis.

### Oceanography

Mangine of Gulf Streen Bines with Altimuty

Jost at Joi Propeleian Laboralary, Colifornia Jostituta of Tochnology, 4866 Och Gyovo Privo, Passona, CA 911091

The dynamics of Bolf Strose Bings during Sundot, 1976 are smealed waing combised SEASST and BECG-] altisatey in too merthwest Atlantic. Aitisatele heights are used to may the genetophic nessures and the profit of the surface height realdusts with too pool to a

Geostrophic surface ourrant tiside ere graduoud from the height residuais. Saids a ions-tore man surface for the region, generated by weing eaveval years of ONOS-] milmatry, we attempt to magnure trootect oddy/mean Tiow necessive scobeage. Advaracies exacoleted with these mitterlo ampping methods are potentially comparable to those atteins for many of the surveys. Suggesties are made for using GROSAT (altimatric estailise to be immedsed in 1984) to afvery ting dynamics.

Constal Current Energatics

University of Alaska, Pairbansa, AK 99701)

The Alaska Cossiel Current is an energatir, narrow had of brackish water which flows weatward along the moretarn Ouif of Alaska. Its source injusts are the high rate of frashwater runoff from the count and the longabore ensemity vind. The treshwater influx runges as a rrose-shelt dessity predised which drives a longabore had been to reserve the brackish water into a nerrow had end thus malateins the integrity of the flow. The trashwater input is created as a finid capacitar, where manny is stoned by virtue of a pressure gradient, which he usedeque to an alactrical capacitor in which the energy is erored due to a voltage gradient. Expressions are derived for the wherey distribution to the constaint where so, a fourion of fromtweat infine and wind stress. Serty sericates are sade low steedy-state and trenslent scenarios and they compared to observed values that one setimated from a set of hydrographic stations.

The calculations indicate so appreciable vertation is compared another another another another works.

Recoins of Sulf Street Blots with littlestor.

d. L. KITCHEL.

O. H. Bost
| both at Jat Propulsion Laboratory, California | lesitote of Tacknology, 450b Oak Orova Oriva, Passdana, Od 911091

The dynamics of Oulf Street Rings during August, 1978 are exuaised buing combined Righat and GCG-1 allighter. In the northwest stlends elicimbeld beights are used to mad, the godetrophic see Savies beight readquals with temponic to a regiment good, insucts compare (everably eth) conservant hydrographic surveys.

Geographic astrone current finide are produced from the height residuals. Calag a long-term date surface for the region, geometric by using especial years of 2008-3 allinately us attempt to measure translant eddy/ashe flow momentum withheade. Appropriate as equitable with these attimetric

mathring dethods are potentially comparable to laces estainable from Openographic curveys Omgazations are mid for wang thick (sittains) an estain to an issued of 1985) so gody ring

EST. 4 THE SHEET SHEET AT THE ACTS OF HE ESSE PATTER REST SHEETS TO THE TENDER SHEETS HE GENERAL CONTROL SHEETS

R. MITTERS, J. 180500 (180, P. 18050), R.D. BALASO, P. GEORGEO, J.J. (15 1171), L. 200614, J.J. ROSTEN, J.J. (1804) O., J.C. (1804), J. P. (1804), Q. W.-OD.

A adversable stude of a fast speciating the original high-factures they suggest that he discovery of intense hydrothers of antister it est Paritic Disc pare 12 5000.

the hydrother at deposite found in the central games are followed to face formed tapidly for the order of face decaded, because it is an active fill enabled by the office of the proof of a settle of the tapidly to differ the position of a settle of the tapidly the file of tapidly the tapidly the tapidly tapidly the tapidly tapidly the tapidly tapid the constrained of the major relatible phases the major and full disolved in the celling for childs (25) Cl is about 0.80-813 g. opt liter. From an increase that the cost of colline of the 17-cc. If its outboard that the cost of colline probability along the liter of the 17-cc. If the order of the liter of the colline of the 12 king, pet day.

the rest extender hedrothered deposits were discovered an another is recovered to careful that of the tible axis. The hydrotherend deposits frank or both fridge axis and or the account are shally in contributed and contributes accountially of glass, copper and too historial school.

Seismokogy SELECTION RESERVE

Microsologicity Bear Manualtanies, Chilingine

A.T. Saili II Cowernes L. Permure Nollismi Laboratory, P.C. Bux Rist, Livernore, 2:A 94550

Integratory, U. Iver Rist, Livercurer, I's ground I burling August 1987, a scientis network of Maintina was accepted noor Manageth Lokes, Mallorais, in the min of overal aways activity within the fact variety 10 depts. Incircument a incircled varieta and 2-muspengul volently i reasonaters, and a forced-balanced ecologoment of Mallorais recognist of 189 acomptos/necond on Succeptation III-180a with an sixy-irigger ordical of object local noise and to insure ecuacio relative limitet.

The network recorded UNIS calculation since running north mingr US 395 from these Highly and each noise running and work recorded UNIS calculations are been of small choic near noise general to determine the incircle velocity structure, a saids of small choic near one's general control provided from sources. Hundreds of local carbiquekes were also recorded to at least magnitude 3.

enorded to at logs) mognitude D.

addition, e sworm of evenin was recorded on August 9. & climitaneous inversion determined hypotenics, sisting ofmultaneous inversion determined hyposenters, sisting acreet loss, and volcetty structure i Roseker, 1911. The The avents occur during a three-hour period clost s \$1.5 km argment of the plane end between depths of 2.5 and 3.5 km. The maximum USGS code magnitude for these events is 1.5. Additional avents cour to depths of 9 km, but not directly below this events. The deeper epicenteriscale from 0.3 to 1.6 km from the owarm epicenteriscale from 0.3 to 1.6 km from the owarm epicenteriscale from 0.3 to 1.6 km from the owarm epicenteriscale from 0.3 to 1.6 km from the owarm epicenteriscale from 0.3 to 1.6 km from the owarm epicenteristic the configuration events above the tupestion where the stresses are highest the deeper avents occur alors the perimeter of the upwelling. Focal mechanism and the perimeter of the upwelling. Focal mechanism are stantial ton during a proposed to constrain the origin of the events.

Work performed under the employs of the U.S. Opperiment of Energy by the Lowrence Liverport, Netfornit Laboretery under contract number W-182-2 NO-48.

Applitude Coupling and Francesov Shifts for Frances

CUT MASTERS | inotitute of Geomysico and Planetary Red Scripps Leelttution of Commonstaphy, indifferent Scripps Leelttution of Commonstaphy, indifferent Scripps of California, Son Diego, La Jolie CL 4909) JEFF OMEX (also et IOFF] FREDMAH CILBERT | plac et IOFF]

It has here known for more years that the Grief force caucas quasi-degacerets coupling of granding ands if their degenerate frequencies are dice some that has not been praviously realized is that this with the not been praviously realized is that this with the not been praviously realized is that this with the service of the coupling in that nodes which are usually according a spherical sodes has a toroidal conjugated a spherical sodes has a toroidal conjugated and vise versa, for example, the modes 7c.21 pages and vise versa, for example, the modes 7c.21 pages in the frequencies and etchnistions of these spherical modes are strongly effected by the conjugate is apharorial modes are strongly effected by the conjugate is affected on them granity is and selected with a surface on them granity is and selected with a page that we want to page the conjugate the page which received in peace of or sear toroidal and principle on vertical components. If so went is frequencies on vertical components. If so went is

Maria Cont

particularly good at smolting low frequency toroidal sodes those peaks can be very large. Rotation of horisontal component solobugases also shows that the educating local to peaks of the treasverse components at or near epheroidal mode frequencies and peaks at or near epheroidal mode frequencies so the longitudinal components. These recults have superient implications for the problem of farth structure retrieval as data which have been regarded as appropriate few retrieving the appropriate few retrieving the coupling. The amplitude coupling must also be included when retwieving the moment tensor for shallow eracts at low frequencies. SPR-Magnetospheric Physics

long Plaing Districtes to a Kedlum-sized Vectors Chapter

R.V. BOSKELL Places Thysics Laboratory, Australian Marigns) Toburrity, Gobbarro, Australia <u>1.5. WELLOGG</u> (School of Physics and Astronomy, University of Minnesots, Minnespolis, Minnespots

Observations of beam-plasma interactions have beam carried out in WHOAT, a vature chainer at Ameralian feel local University. MOMEAT is 2.5 matter long and determined the termined and matter observations, and has a magnetic tight of up to 200 gausa. An alection beam of mantry up to and my and cutrects to several an was used usually which an interaction thaugh of a upder. As the cutrent from the gam is interassed from a termines 5 to general wh, three seemantally discountinuous transitions on charved in plasma Sensity, implically, plasma volume, and/or 5.7, emissions. The tires ground tion flowest turnout seems to correspond to that found by Bernstein at al. It waste main at pressures below about 2 10° Torr.

The C.P. satesions are very spike and agen to be what is expected for solitons. Plasma section acceleration and beating is then-correlated with shore spiles.

Sernstein, M., teinbach, B., Hoteön, O.J., Malliagn, T., Garriott, O.K., Konredl, A., NcCor, J., Baiy, P., Spier, B., Radefoon, H.A., Kallarg, P.J., Electron Sean Injection Expariments, Georphys. Res. Letters, 2, 127-130 (1978).

5951-17A

the Geometry of the Hannetosphere. [1]: Topological impects of in Entended-Tail Charpin-Parrays

It was augusted by Yostworth [1957] that the clearical Chapman-Farrero problem say here so "artended-Lail" solution, in addition to the thoma solution [1950] "tear-drop" generatery. So attended-tail 6-f magnetocavity canotitates a "ground-siste, save-order" solution, with addition of an NO representing a "[ine-order" porterbation. One experimental gas "ine-order" porterbation. One experimental light on this problem, said it it is purposed this paper to develop qualitative tapests or the topology of this ground-stele, extended-tail C-F signitosphare.

First, a quantitative existance proof for the artended-tail impology is developed. Them, a ricensity-observed high-latitude 'governed-traping' of und-solar boundary-leyer field lines say as asturel aspects of the CF entended-tail impology. Finally, dynamic processes which are aspected to take place it the sero-IMF, sytemeod-tail tagnesmaphore are briefly

SPR-Solar and Interplanetary Physics

Dependance of Spectral Content in the Pc 2-4 Fraguency Range on Interplanetary Magnetic Field Intensity

h. ECHEPHE () nutitute of Geophysics 1 Planewary Mysics, University of California, Los Angeles, CS 9602t;

Among various solar wind piceus and interplusatory augmont; iteld [197] parameters the inter-it, if II; has been experted to flow a strong ettest on the frequency of Po 3-t argestic pulsetions observed on the ground (Freitstays of al., 1871). These observations indicate their pulsetion traguncy is the ground [Treithtays of al., 1871]. These considerables indicate that pulmetien its greency le proportional to SMF Intensity. In this resport we investigate whether a siniter TMF affect switch the To 3-4 magnatie pulsations is again codesaved by the Synchrosous satellite ATS f. th order to avoid the synchrosous satellite ATS f. th order to avoid the synchrosous satellite ATS f. th order to avoid the synchrosous satellite ATS f. th order to avoid the synchrosous satellite ATS f. th order to avoid the synchrosous satellite ATS f. th order to avoid the synchrosous satellite ATS f. the order to avoid the synchrosous satellite ATS f. the order to avoid the satellite of the selection of the standard frequency of its satelling the 2nd and 3rd the stonics indicates a positive consistation with the Intensity, but maither solar wind valocity ser IMF dissocition occase a significant change is the power ratio. Our construction is in accordance with those made by the Russian valenchard. However, the Saguancy of the how-shock-sencelated spatters wave satimated using a model for passine raficotion at the how-shock sence is the spatters wave satimated using a model for passine raficotion at the how-shock sence is the spatters wave satimated to the spatters solar wind iMelandae and Tatecows, 1961; come to hove little correlation with the power rotto. This result argues against the hypothesia that the upstream were is disactly related in the frequency of regrasionspheric Pr 3-t pulsasions.

### Tectonophysics

TAZA-05 REVISED

Crrice 1. V. Alken Univ. of Texas at Dallen, P. O. Box 585, Michardson, TX 75080 G. Hardy Kelter [Univ. of Texas at Ei Peso, Bi Paso, TX 75768 Robert Coultrip (UTEP), Chender Abuja (UTO), Hing-Roo Hong (UTO), Darid Yoogalf (UTD) Hong HTD) Darid Yoogalf (UTD) CA 94(1):

GRAVITY STUDIES OF THE PARADOX SASIN

The transibility of untug the Paradox Basin for vacloselfve wested disposed prompted fra sequisicion, nerging and soliting of date from 50,000 gravity stations and now Occhemical smalluss for major- end trace elements therein contractions from 10.000 eractions for the Cochemical smallure for major- and trace elements that no states and now terrain corrections from 18.000 stations for the status of Coloreds and Utch, and sidecant areas. Bouguer and realdust map once produced. Regional Bouguer announces once operated to regional bouguer responset on regional copography, and the shortest wavelength correlation is along that wavelength is then used as a variable reduction deturn to pradire the correlating ascency which is then considered responsely by a var Coloreds with the broad regional topography; high te seen. The represent correlation of a broad growing how aver Coloreds with the broad regional topography; high te seen. The recreasing he northwest Utch. The resultant announces the major process the most become an expension of the security when one considers the different residual announces, the produced with the state of the security when one considers the different residual announces, the produced with the state of the security when one considers the different residual announces. Postoromium black state of the security when one considers the different residual announces, the state of the security when one considers the different residual announces. Postoromium black state of the security when one considers the different residual announces of the security when one considers the different residual announces. Postoromium black state of the security when one considers the different residual announces of the security when one considers the different residual announces of the security when the securit throw textures such as the broad besing and uplifus. If the codimentary rock offects are removed, a large contineous high (+50) is even orar must of Utab and Colorado. The Perados Sesin itse toward the south time to the cast-west boundary of the high which destroases abruptly slong the Arizons-Now Mesico border. The Perados Sesin region irosif is not accomplous. The most significant interesting the secial secondinal superingonad on this high era a north-south iow sions the Mosetch from tousidered by some to be due to the complex juxtaposition of seversi deep features, and a northeast-mouthwest low along the Colorado Kineral heir. Excalient cortelations are seen with the strengentic anneally maps, the most interesting being prominent east-west Lincotions. Various (fittored tags of the residual Zvavity bave size haso generated and analyzed,

Three Leave of French Sex-Beam lotivities

C. Soly (Castra Scass De Statagne, Brest Cadex The Ditto (Franch Sational Center for Comm's Exploits (as) he sempled the Satesard Yarsel dans Curret with a multi-harm mora dis-blest in 1977. He has naturated the MOD [Sursey Mational] das Donness Countywes to develop a software for processing and troblying 464-bene 661s; that semps:

- Post-processing of data, makers on his computer, for containing plone the shiple treat,

- Foat-processing, at see so mini-computer.
- Semi-time contouring with integration of
navigation date.
- Blaborgatop prepartations: block-diserce, image
processing, colored maps.

St great tips, the MDO mas archived simple all the ess-best date collected during Jan Charact's cruinax, that menus about 1,000 days and 350,000 h)locaters of protiles. This smooth is reseated in a

this taken so-line, the exploisation of data by lange processing trobholos, the plot of coinred aspa, the automatic fitting of navigation with members bethype(ry ere our principal ways of ferelopment for

Induted Scientity at the test on Hill Not Dry York Site e, Kipprie, t. PESRSON, J. SCERIGNI, R. PDITES, F. sGNuje | Earth and Space Sciences Divisios, tos Alexon Metional Cabonatory, los Alexas, Add S75151

Metional Caboratory, Los Minnas, NM 57851

Microseribquetas recordad Guring hydraulic fracturisq enpariments in 12-2, tos Isjection well of the new deep 'Englaceriog Beaserole' [58] at Lenies Mill, offer in sayaral important ways iros microserthquetas reserved in the sarihiar 'Research Reservoir' [58] systems were generally vertical, the seems lossions in the first and the sarihiar 'Research Reservoir' [58] systems were generally vertical, the seems lossions in the first systems were generally vertical, the seems lossions in the first sugast a series of an-acheion 45° dioping fracture places, which strike sitentify ett. Los serten, similar to the 68 fractures. This aread is quite well of fined in the lower [575-435] a depth) part of the fit, begoning eure isolisiect in the upper [3257-3527 m) intervit. This change in fracture orientation but be explained by several hypocheses. First, these Objoing fractures may imply a change in 15e orientation of the ministry congressive stream, perhaps associated with tolispes of the nearby veiling Calders. A second possibility it that these tractures may represent from the first perhaps associated with tolispes of the nearby veiling Calders. A second possibility it that these tractures may represent from the first stream of the second possibility it is the these tractures may represent from the first strike during head and the first strike the second possibility in the these tractures of the figure of the second second second using least weets the second second of farces to the second se

CROE 2 Large Apertury Spismin Survey

4. LC DOUARAM ICLI-Coultrains, Your Sandraie, La Délance, Paris, Irantel J. Busaus Libert (su Frantais du Pârole, 92506 Nuell-Malaston, trancat Cientre dedenologique de Breregno,

of Western Fedicerranean Sealin.

B-refractions and greenited reliections were
observed even from 188 About Desgine presence of
halfocingtic Messimian safe layer, and have deen
used in the will conside the velocity structure
of both sedimentary Cover and crear,
incredifferent deglocated domains are distinguished in thick continental domains, with a
aboutly a bull will also a backness of 20 km,
continued sewards for a structured continental
Command sewards for a structured continental
Command report of the basin A combinate and search sewards.

The atretched continental comein is very wide in the Buil of Lips (180 bell and considerably reduced in int of the lead of the larger data for term of igocens

Volcanology, Geochemistry, and Petrol-

Stable Isotope Compositions of Riangus from the Juan de Fyca Right

7015-155

SASK, Canada
Siamay rims of sight pillow laws dredged from the
Juan da foca Bidge have ED values that range from -84
to -54 permit. A positive correlation between the
desterium and water tentents in most of the samples
magnetic stad the range in 40 without a primarily the
reselt of the addition of seweter in magnetic 00
values mer -80 and maker contents of 0.2 wt. percent.
At least two of the samples have also lost CM, or 4)
because they are enriched in deuts-rime but depleted in
unter reletion in the magnetic values. Sit relues
are also carlable (-24 to -12 permit) and the "C conJones Increase proportionately with the concentration
of contents may be attributed in the differential loss of
CO2 which is excited in "C relative in the
discolored in the gless. Although varietions in the
discolored in the gless. Although varietions in the
discolored processes, the toestent of "O relues of 5.0 of
the glesses inditate that oxygen isotopes probably relact the isotopic composition of the source of the
isves.

Evidence ter soltiple processes in the securion of cale-atkailus isvas from Santorini, Cyclades, Grace.

University of Otracht, Departmoot of Geochemistry.

ilection is suggested as a possiblity for the rooeteory of enaposition.

Voltanic Ash "Clusters" to the Stratoschere Aftse the El Chichen, Mexico, Eruption

B.S CLANTON, Booding, J.I., and Blancherd, D.P. (MASA - Johnson Speco Center, Code SM2, Housian, 11, 77058)

On May 7, 1982; Project Airstream flew 2 cosmic dust collectors for 5 hrs. At altitudes of 17 to 20 km and over 300 to 490 M letitude and collectod~2.4mg of and from the April 4, El Chithon eruption tioud. Hetertal octured both as distrate shards and as composite "ciustere" of shards, individual shards ranged from .8

to 19.5 µm in length. Long-onis measurements of 300 particles gove madian, 7.5 µm; leavass, 0.497; kurtoals, 3.88. Measurements of 484 clusters geve a verge of 10 to 100 µm end o modian of obous 30 µm. Calculations using Stokes' low long that particles St. ofication using Stokes' low long that particles St. ofication should have settled below 17km by the time of sorpis collection. However, calculations based on the Wilson-Huang equations for imphre settling woold parmit irregulor partitles up to ~12 µm maximum dimansios to have remained at or above the collection of the massimum distance. Headured sizes of tollectad particles can be undershood, in part, using the Wilson-Huang model but "tiustar" formolion any also be required to amplian the capsitude of the size amoundly. Clusters form a fragilar structure with an apporent effective outly damalay <1, much lower than the 2.5 g/km² value which probotiy applies to individual shards. The fragils cluster structure indicates formation in the stratostare, possibly by electrostatic charge. A Stratesphesit obundance of 30 ng/m³ lor, 200 portitle/m³ list colculated for the ash et the time of collection. The disension of the ash et the time of collection. The disension of the asd on particle is about 7.5 n 3.2 x 1.6µm. A setost collection in July, 126 days offer the arupilon, continued to show partitudes.

interaction between etid 'Tuscan' and potentic 'Roman' maguag in the voicenic system of Ht. Amiato (lasty).

H. BARTON and H. J. VAN BERCES IVaniss Melmoss Lab., Utraths, The Matheriandel.

the ash in the miratophere ea a function of time

C.GREZZO and C.S.BICCI limitante di Sinarelogia e Petrografie, Slene, Italyf.

Rhyadetitic isvas from Ht. Amiete volsenic complex (Southern Tuncant, Italy) comisin abundant minuite (mica and K-rithi technologs, Major end trace alegent data display continuous rariation between the minute incluelons, some subordinate mails lettle leves and the rhyofecisic hoci large over a range of 48-672 Bio. Al. Pa, Ha, Ma, Ca, Ti, P, Sr and Ba decrease with increasing Sio,, while No used Climtrease, and K.Rb. Zr.ta, Co.hb

minette and letites are senturative and chamically identical to the phanocryata in the shyodacitys. Patrographic minerological and chamical avidance indicates mages mixing, resulting from injection of mafit mages into a silicic magnathember, es the process responsible tor its chemical vertailon. The sold mining endocuber is the SiO--victors rhyodecite from Mt.Amisis, boiona-The maffic andmomber has tions atfinities to the polaselc sitaling leves of subvrusiol origin from the edjatent Roman Drovisco.

Analysis al E-Type Carebqueles and Explosione at Paviat Volcame, Aleska

5. NCEUTT

J. MGR) itemosi-Doherty Gaological Observatory and
Depriment of Rectogical Sciences of Columbia
Valvacaity, Felloades, New York 109641

Valversing, Fellander, New York 109641

An eight-statled natural of shart-parind selementary nas been aperated natv Paviot Voleme, [55°25'v], 181'34'v] alasts Sankauste since 1856. Eigh quelty saaing to digital and direct digital data were records during stagitions in 1860 and 1881. We assigned being from englouisms with Distance air phases and from b-spe weicasts earthquake ishalkow, low-treatency overs lacking clear 3-phases) to determine source and yrongestion effects. Setween across dewards bunders groups are recorded, with signer numbers during symptoms. Regultudes cauge hatween -0.t and i.d. each b-values range between 1.7 10.1 and 5.5 t 0.1.

Live rasults are most important: 1) Bars tross analy learning are component atalion reward that the highest-amplitudes usees o) the 5-type events above retrogreed allipsied particle motion and correct discount of the events made retrogreed allipsied particle motion and correct discount of the events made average the second and correct seconds of the events made as a serior of the events and the heart proposed allipsied particle motion and correct the second account of the events and the second and the second and the second and the second accounts and the second accounts and the second accounts and the second accounts and second accounts allowed to categorical accounts and second accounts and asserted as a serior greater than one accounts and accounts and

# Classified

and I are virtually constant. Monocrysta present in th

Raice Per Lines

Positions Worted First unsertion \$1.75 additional insertions \$1.50 Positions Available, Services. Supplies, Courses, and Aenouncements First insertion \$5.50 additional insertions \$2.75 Student Opportuni tita First insertion, not otherwise automaced, free. Additional insertions \$1.50.

There are no discounts or commissions on classhed ads. An orpe that is not publisher's choice is charged for at general advertising rates. For is pulslished weekly on Tuesday. Asls must be received in writing on Monday. I week prior to the date of Decide at tour

dressed to Itox \_\_\_\_\_. American Geophi sical Union 2000 Florida Avenue, N.W., Washington, D.C. For further information or to place an ad rall tell free 800-124-2488 or 462-6903 in the Washington,

Replies to ads with hox mutibers should be ail-

POSITIONS WANTED Reflection Selemologiat. Recent PhO in reflection neismology looking for a reacorch associate position. State-of-the-ort knowledge of wate propagation, data processing, ond computer graphics. Send replies to Box 015, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C., 20000.

Hydrologist Seeks Consultiog/Research/Tenching Position. MS (terigation Engl, PhO IAg. Engl. Three years experience in computer model applications in hydrology and data processing. Box 016, American Geophysical Union, 2000 Florida Arenue, N.W., (Vashington DC 20009.

POSITIONS AVAILABLE

Assistant Research Oceanographer/SIO. The Ocean Research Oivision of Scripps Institution Oceanography invites physical oceanographes to peply for a position as Assistant Research Oceanographer, the research equivalent of Assistant Professor IPh.O. In physical sciences or equivalent degree required. Candidote must have strong background in applied mathematics and fluid dynamics; strong interest in ocean dynamics; and proven research and publication record in physical oceanography

This position is lunded through ONR constant to two years. Appointment beyond two years is contingent on catchidate obtaining extendinal appair. It is expected that the majority of research effort during the two years will be deruted to the theory and soulpsis of data on Kuyosho variability. Salary range is \$22,000-\$26,800 continuously 40,83 Please send resume and at least three references to Dr. Russ Davis. Chairman. Orean Research Univious Dr. Russ Davis, Chairman, Ocean Research Hysision Au30, Scrippe Institution of Oceanography (E. L.; Jolla, CA 92003 by March 15, 1983, For additional information about the position contact. It. Peter Niller (619) 452-4100. The University of California, Son Diego is an Equal Opportunity/Albrutance Ar-

Physical Oceanographer/Oregon State University. Assistant or Associate Professor, depending on experience. Applicants may be observationalists or theoreticians but must have a Ph.O. In the physical ecience, have demonstrated the ability to conduct independent high-quality research and are expected to obtain research funding. Duties include reaching and supervision of graduate students. Interested candidates should submit a resume and names of three teferences by 1 Match 1983 to: G. Ross Heath, Deon, School of Oceanography, Oregon State University, Corvallis, OR 97331.

Affirmative Action/Equal Opportunity Employer.

Faculty Teaching and Research Position/Institute of Marine Science, University of Alaska, Fairbanks. Research interests should include the numerical modeling of estuarine, coastal and open merical modeling of estuarine, coastal and open ocean physical oceanography in subpolar or polar environments. Participation in interdisciplinary studies is encouraged. Applicant should have an extensive background in hydrodynandes and numerical modeling. Ph. O. degtee in physical oceanography is preferred for its equivalent in training or experience. Rank and solary will be determined by experience. Candidates should send resume and names of three referees to: Dr. Vers Alexander, Director, institute of Marine Science, University of Alaska, 99701. Closing Date March 15, 1985.

The University of Alaska is an EOAA Employet and Educational Institution.

Yout application for employment with the U of A may be subject to public disclosure if you are selected as a finalist.

# MIT FACULTY POST IN ACOUSTICS

The Department of Ocean Engineering Invitee applications for a facully position in accustics, at aither the Aseletant or Associate Professor level, affactive September 1, 1983. Teaching responsibilities will inciuda graduata education in acovetica and participation in ralatad programe in polar angineering, marine aenaing and information systems angineering, or underwater systems dynamics. Reae arch will involve experiments at sea, including work in the Arctic Ocean, aboratory efforte, analysia of computer-based data, analysis and modeling, and/or theory building.

Candidates should have an advanced degree, prefarably a doctorals in acoustics or closely related field. Research experience in one or more of the following accential: propagation of cound in the ocean, both Iheoretical and experimental; acquello ecettering proceases in tha ocean; ambient noise mechanisms; behavior of acound in ice-covered waters; communication, information, and eaneing eyeterna; ehip notae radiation and control; flow noise.

Candidates should submit complete resuma or curriculum vitae along with liet of professional references, and reprints of two papers representing work in accusatics. Closing date for applications is April 1, 1983. Application materials should be sent to: Prof. fra Dyer, Chairman of Search Committee, Massachusetts Institute of Technology, Rm. 5-212, 77 Massachusetts Avenue, Cambridge, MA 02139. Mili is an equal opportunity/affirmative action employer.

State of the contract of the c

Naval Postgraduate School. The Department of Oceanngraphy Invites applications for the position of Atliance Research Professor in the Ocean Turbuof Affunct Research Professor in the Ocean Turni-lence Laboratory. The successful applicant will be responsible for the organization and execution of oceanic turbulence measurements as well as the in-terpretation and reporting of the ultained dan. The position requires a Ph.O. or equivalent in Phys-ical Oceaning raphy, 8 jears in post-doctural eapen-ence with oceanic measurements and data interpre-The positinit requires a Ph.O. or equivalent in Physical Oceaningraphy, 8 jeats in post-floctural capenence with oceanic measurements and data interpretation, and some tamiliarity with unbulence instrumentation. The Ocean Turbulence Laboratory is actively engaged in the accasinement and interpretation of oceanic turbulence data front a variety of cortronneuts obtained with several type of rehiclet. The successful candidate will be expected to contribute to the growth and development of the srope of the secarch performed by the laboratory.

Applicants should send a resume, statement of research record and interests, and the names of at least three references to, Prof. Thomas R. Osborn, Code 650r, Naval Postgraduate School, Minnterey, CA 93940.

Applications will be considered until Morch 8, 1983. Application will be considered until Morch 8, 1983. Application of Professor Christopher N. K. Mouers, Chaitman, Department of Cennography, Naval Prastgraduate School, Monterey, CA 93940. Phone: 1408) 046-2552/2553.

An Equal Opportunity/Allirmative Action Emplement

Research Associate/Upper Atmospheeic Phys-tes. The National Research Council (Canada) is buibling a multi-instrument ground based sescerch tacility called CANOPUS. One part of CANOPUS is a Data Analysis Network which will provide Interac-dive access to the CANOPUS data by scientists across

the access to the CANOPUS data by scientists across Canada. A research associate position exists for a person with world be associated with implementing and operating this network. This position will allow same independent research muspects of the TANOPUS data and the holder of the position would be entitiaged in mulertake such research. The position requires a PLLD, in some aspect of tipper atmospheric physics (prefer ably ground based) and extensive magniter experience. Any related experience in computer retworking, etc. world be an advantage. The initial slary will be in the range from \$54,000 m; \$27,000 per year, depending on capacition. The appointment will be initially made for two years and conjugence as soon pending on caperiome. The appointment will be initially made for two years and confinences as soon

as prisible. Send resumes and the names of three referees in:

Professor J. A. Koehler Institute of Space and Atmospheric Studies University of Sarkatchewan Saskatoon, Saskatchewan S7N 6WO Ganada.

Assists at Professor/University of Alberts. The Department of Physics at the University of Alberts Invites applications for a tenure track position at the fevel of an Assistant Professor in Physics at any of

level of an Assistant Professor in Physics in any of the fullowing areas:

). Astrophysics and Astronomy;

2. Geophysics (Electromagnetic method);

3. Theoretical Physics (Medium Energy, Particle Physics, Reliably and Cosmology).

The 1982/83 adary range for an Assistant Professor is \$27.729-\$39,820 per anoun.

Application will be received until May 1, 1988, and the expected apploitment date is july 1, 1988, The Department of Physics offers both undergrathate and graduate degrees in Physics and Geophysics The Department currently consum ab 47. Faculty Members, 3d Research Associates and Post-Ductoral Fellows and 50 Chaduate Students.

Candidates Interested in applying should submit a curriculum sitae plus the names of three (3) referees

Or. A. N. Kamal Chairman

Or. A. N. Kamal
Claiman
Department of Physics
University of Alberta
Edmunton. Alberta, Canada
T6G 2]]
The University of Alberta is an equal opportunity
employer lan, in accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

University of Kentucky/Department of Geology - The Department of Geology invites applications for two tenured track Assistant Professor level positions. Both appointment are for soft rock geologists preferably with some experience in Industry and interests including one of the following: sedimentology, strangerathy, carbonate petrology, organic geochemistry, or isotope geology. The successful applicants would be required to participate in active research, supervise graduate students and teach graduates and undergraduates. Familiarity with quantitative techniques is desired; Department has access to a variety of computational devices. Academic ritae and natures of three references should be sent to Or. Lyle Sendlein, Chairman, Search Committee, 32! Patterson Office Tower, University of Keotacky, Lexington, Kemucky 40506-0027. Closing date is March 1, 1983, Both appointments are to commence in August 1983, but an earlier are to commence in August 1983, but appointments are to commence in August 1983, but an earlier date may be considered. Salary is negotiable.

The University of Kenturky is an equal opportuoity/affirmative action employer.

Virginia Polytechnic Institute and Saste Universi-ty/Structural Geologist. The Department of Gro-logical Sciences invites applications for a tenuse-track marition in Structural Health and the Addition track position in Structural Leology at the Assimation Associate Professor level. The position involves teathing at the graduate and undesgraduate level and supervision of graduate smelett sessarch. Candidates should be process-uniqued with interests in field related problems. A Pls. D. and strong research potential are required. Closing date for applications is April 15. The position is available front Septemary, Transpagements.

ber 1, 1983.

The apply send a vita with list of publications, num-many of present and proposed research and the names of three references to: Remedi A. Erikston, Chairman of Search Continuitee, Department of Geological Sciences, VPI & SU, Blacksburg, VA 24061.

Affirmative Action/Figual Opportunity Employer

Paculty Position/CSM. The Departments of Geology and Geophysics at Colorado School of Mines anticipate an opening for a joint appointment as Professor of Teology and Geophysics to continence September 1, 1983.

The successful applicant will be expected to teach courses and conduct research integrating exploration geophysics with petroleum geology. Applicant though possets the Ph.O. degree and responsible experience in explorations research and teaching. A resume and references about be forwarded to Dr. J. Finney, Head; Geology Department or to ment; Colorado School of Minesi Golden, Colorado 88401. Closing date for applications is, April 15, 1983.

393. Polorada School of Mines is an Affirmative Action Equal Opportunity Employer.

### Marine Geology & Geophysics

Wooda Hole Oceanographic Inati-tation invites applications from researchera scrive in the fields of marine geology and geophysics to fill available positione on the scientific staff of the Department of Geology & Geophyeics. We eack applicants at a broad ranga of experience levels, from immediataly postdoctoral to those with ten or more years' of industrial or academic research experieoce. Our intention is to strengthen over the next year the department's active eerth sciances program by meking steff eppointmente in manna geology and geophysics.

The Institution offers excellent facilities to carry out the full epectrum of practical and theoretical marios eerth science research. A strong interest by candidetes in conducting seegoing programa is preferred and a cepebility to conceive, fund and carry out independen t research programs is required. In addition to Geology and Geophysics, the Institution consists of four wall-setab liched research departmants epecializing in the fields of Biology, Chemistry, Physical Oceanogrephy, end Oceon Engineering. Colleboretive research with the mambers of ateff of these departments is strongly encouraged. Opportunities also exist for participation in the joint Maesachueetta Institute of Technology - Wooda HoleOcee nogrephic Inatitutioo graduelelevel education program.

Applicanta should send resumes and names of three professional referen cee lo:

Personnel Menegar Box 54P



Woods Hole Oceanographic Institution

Woods Hole, MA 02548 an equal opportunity supplying M. F. H.

The Ponnaylvaula State University/Faculty Poatiloua. The Department of Geosciences invites applications for three (3) tenure track faculty positions, which are expected to remain open until filled
by outstanding geoscientists in any of several fields
of specialization. The faculty rank associated with
each position is presently open, although talary
funds currently available are sufficient for at most
one senior full professorabip. Salaries, which are
competitive, will be tornmensurate with the experience and qualifications of the appointees. The sucresult candidates must be, or have demonstrated
the potential to become, nationally recognized leaders in their fields. They must also have an interest
in teaching and advising graduate and undergraduate students. Petrons having an interest in collaborative research with other depanment faculty are preferred. Instructional and research areas in which
particular needs have been identified include, but
are not necessarily limited to: aqueous geochemistry,
with emphasis on low-temperature rock-water
(groundwater) interactions; heavisolophysical geochemistry,
with emphasis on global geophysical and geological processes and observable manifestations of
them; sedimentary geochemistry, with emphasis on
quantitative aspects of carbonate petrology or clay
mineralogy; X-ray ministalogy, with emphasis on

dentiative aspects of carbonate petrology or clay mineralogy; X-ray mineralogy, What emphasis on pet-

atmoaphatic, ionospheric, magnetospheric phenomana of interest to the

Dapartment of Defensa, Research em-

phasizas the solution of problems in

high altitude nuclear effects (HANE).

Total Comment

NRL

## THEORETICAL OR EXPERIMENTAL SPACE PLASMA **PHYSICISTS**

## NASA-MARSHALL SPACE FLIGHT CENTER Huntsville, Alabama 35812

Two positions in theoretical or experimental suaca plasma physics are available in the Magnetospheric Physics Branch of the Spece Science Laboratory at NASA's Marshall Space Flight Centar. Either theoretical or experimental backgrounds will be considered with a preference given to theoretically oriented researchers to complement the extensive experimental activities of the branch. The Magnetospheric Physics Branch is involved in the applysis of lowanergy plasma data from the ISEE, SCATHA, and Dynamics Explorer satellites, from sounding rockets, and from the Space Shuttle (STS-3). In addition, the group is presently carrying out the joint development of a variety of active space plasma expariments that will be flown on Spacelab One, Two, and Six.

Salaries range from \$34,930 to \$41,277 per annum, depending on experience.

Interested applicants may contact Dr. Charles R. Chappell at the Marshall Space Flight Center (205-453-3036). Forward resumes to the following address not later than

> NASA-Marshail Space Filght Center Space Science Laboratory

Attn: Dr. Charles R. Chappell, ES51-R2 Huntsville, AL 35812

NASA

An Equal Opportunity Employer

U.S. Citizenship Required

rulogical applications of a (Mallochrungal mediculs) and modeling of dynamical carth princeses using ap-propriete physical and mallemantal representa-

tonis.

The selection of persums to full these three positions will be based in part on the extent to which
their future research efform will complying and
further strengthen our programs in Greatmentally
and Mineralogy, Geology, and Geophysis. Qualified persons should, therefore, inclinde a brief description of their future research objectives with
their resumes and the names of three references,
and send to:

and send to:

C. Whyte Burnham, Head
Department of Geosciences
The Pennsylvania State University
503-B Deide Building
University Park, PA 10802.
The Pennsylvania State University is an afficulative action/equal opportunity employer.

Organic Geochemis/Tho Skidaway Institute of Oceanography. Invites application for a hill-time research position at the position to the associate professor level. The successful tambidute will be expected to design and conduct research related to understanding the organic geochemistry in hear-shore marine sediment and how chemica/hinhological processes in these sediments and how chemica/hinhological processes in these sediments and elements. The position will be available on or after July 1, 1985 with a deadline for application of April 1, 1985, Requirements include the attaiument of n Ph.O. degree in

equivalent research experience. Application mass in that the submitting a resume, a standard of research interests and the names of lott individuals whice an interest and the names of four intermosa whice an he commeted for reference purposes to: Director Skulaway Institute of the canography P.O. Jucy 1968 Swannah, 17A 2141d The Skulaway Institute of the canography is an equal opportunity/albumatice action coupleyer.

Position in Petrology/Rire University, Housion, Tonas. The Department of Geology has a remerence to present the population of the Geology has a remerence of an open and beginning but 1983 white washing beel of appaintment depending on the experience of the candidate. The latenty member it experted to catabilish, or combine a vigations research program in petrology and no paule ignee in teaching in measurements of the properties of the teaching in measurements of the period of the period

**NAVAL RESEARCH LABORATORY** 

PLASMA PHYSICS DIVISION Supervisory Research Physicist GM-1310-15 \$48,553 to \$63,115 per annum (Salary dependent upon qualifications)

As Branch Head of the Geophysical and Plasma Dynamics Branch, which employa 15 scientific and support parsonnel, manages, supervises and conducta research for a broad theoretical and numerical almuletion program in

and the development of models describing etmospheric, lonospheric, end magnatospheric phenomena. Problems of particuler interest are; ionospharic irregularities at high equalorial latituda; magnetic field reconnection processes; 2D and 3D MHD global magnetospharic modaling; auroral iteld lina modeling; anomalous reals livity; lower hybrid drift and tearing mode Instabilities; ELF/VLF generation;

and gravity wava bracking in the masosphere.

Qualifications: A Bachelors of higher degres in physics (Ph.D. prelerred) plus at lass! 3 years of prolessionel exparience in or directly related to the duties described above with one year equivalent to GS-14.

Please submit your comprehensive resume or SF-171 and publice tion list by 15 March 1983 to:

NAVAL RESEARCH LABORATORY NED CIVILIAN PERSONNEL OFFICE Attn: 47-80-13.1 KMO/EOS 4555 Overlook Avenue, S.W., Washington, D.C. 20375

U.B. Citizanship Required

DATA PROCESSING

# Scientific Systems Analyst Denver, Colorado

Sohio's Exploration computing staff has a major challenge for e talentad individual in Systems Design. We need to combina data from savaral data basas Into e functioning intaractiva progrem that our Gaologist and Geophysicist usars can usa to afficiently explora for oil and gas in the vast Rocky Mountain Aree.

Saveral important problems need to be analyzed and solved to achiava our goal of accirate meps. Challenging problems of data flow, plotting, and graphica diaplay will test tha limits of your ebilities.

Wa raquira a apacific background that includes 4 years of programming in FORTRAN with axtansiva use of plotting aquipment and graphics display. Work/acadamic experiences with intaractiva data basas and/or oil and gas epplications would be very halpful. A Bachelor's or advanced dagrae in Computer Scienca, Mathamatics, Enginearing, or Earth Sciancaa is a definita plus. We run VAX 11/780 so any DEC axparience will be positively viawed.

In addition to being a part of e successful enterprise, you will qualify for a compansation packaga including a highly compatitive salary and excellent employee benefits. Qualified individuels will have access to our transfer policy which offara naw hiraa many features that other firms rasarve only for transfarring exacutives. Plaase respond by sending a datailad rasume to H.R., Sohio Patrolaum Company, R7171, 633 17th St., Suite 2200, Denver, CO 80202, Prafarence will ba givan to resumes sant by individuals while thosa referrad by amployment agencies will be held for later review.



An equel opportunity amployer M/F/H/V.

Faculty Positions/The University of Iowa. The Department of Physics and Astronomy audelpaies one or two openings for tenure-track assistant profissors or visiting professors of any rank in August 1983. Preference will be given to experimentalists in any area for the tenure-track positions. Current research interests include astronomy, atomic, condensed matter, elententary partiale, laser, nuclear, plasma, and spare physics. The positions involve the dergraduate and graduate teaching, guidatere of research students, and personal research. Interested persons should send in resume and a statement of research interests, and have three letters of recommendation sent to Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 32242.

The University of Iowa is an equal opportunity/infirmative action employer.

Geophysicista/Institute for Geophysica, University of Teams at Austin. Applications are invited for research scientists with a Ph.O. In the general areas of marine geophysics or theoretical seismology. We are particularly interested in innovative individuals who wish to pursue a career primarily in research with some teaching and graduste student responsibilities. The Institute is located in Austin and operates closely with the Department of Geological Sciences of the University. It is a vigorous and growing group with interests in both land and marine geophysics. Research feelifities include a 167 ship equipped with state-of-the-art multichannel and high resolution selsmic reflection and OOS selsmic refraction espabilities.

Applicants should have a demonstrated ability to

Applicants should have a demonstrated ability to do creative research. Both mideareer and recent Ph.O.s are encouraged to apply. Applicants should submit resume, the names of at least three references and a statement of research plans and priorities to:

A. E. Maxwell, Director
Inutitute of Geophysics
University of Teaus at Austin
Austin, TX 78712.
White late applicants will be considered, we prefer
to have applications in hand by April 15, 1983.
The University of Texas is an equal opportunity! affirmative action employer.

Pastdoctoral Position in Laboratory Astrophysics. The Center for Astrophysics and Space Sciences of the University of California, San Diego is tecking a Postgraduate Research Physicis beginning early 1983. The primary research area will be intertiellar dust grains, with emphasis on their formation, mantle growth and composition, and their role in molecule formation. Both laboratory simulation of interstellar conditions and a theoretical approach will be pursued to extend an ongoing caperiment on the properties of grain mantle analogs. The applicant should have experienre in laboratory practices including infrared spectroscopy, cryogenics and vacuum techniques mans spectroscopy, etc. and also some caperience in computing. The research group has a large body of dain on it astronomical spectra and several ongoing observational and theoretical programs to astrophysics which can provide backup information to the dust grain research. Candidates should have completed a Ph.D. in astrophysics or related field before the end of 1982. Salary is in the range \$18,182 to \$19,848 depending on qualifications and experience. Please send your carriculum vitae, including the names of 5 references, your list of publications, and a brief statement of research interests to Dr. B. Jones, Center for Astrophysics and Space Sciences, C-011, University of California is an Equal Opportunity/Affirmative Action Employer.

Marioe Geophysicist/Teans A&M University. The Department of Oreanography of Texas A&M University will have an opening for a feiture track faculty member in Marine Geophysics beginning September 1983. Preference will be given to candidates with a strong quantitative background in a wide range of geophysical topits and who have both interest and experience in marine exploration.

The successful applicant will be expected to teach indergraduate and graduate contrast and to conduct a vigorous research program in its or her specially. The position is to be filled at the level of Assistant Professor. A Ph.D. is required for this position, Salary is negotiable depending upon experience and qualifications.

Applicants should submit a vita along with a letter describing his/ner research and leaching goals and manes of five persons for reference to Professor R.O. Reid, Head, Department of Oceanography, Teans A&M University, Gollege Station, TX 77843. The closing date for applications is March 15, 1983. Texas A&M University is an affirmative action equal apportunity employer.

Marine Sciences Research Center SUNY Biony Brook/Teaure Track Faculty Position Chemical Oceanography/Marine Geochemistry. We have an opening for an assistant or associate professor of marine chemistry, chemical oceanography, or marine geochemistry for September 1985. Condidates should hold a Ph.O. in an oppropriate field and have their major research interests in coastal marine crivronments. By I March 1985 send a complete resume and have at least three letters of reference sent directly to: Chair, Chemistry Search Committee, Marine Sciences Research Center, 8UNY Stony Brook, Stony Brook, NY 11794. SUNY Stony Brook is an equal opportunity/affirmative action employer.

# **Paleogeologist**

Staff position available immediately for Paleogeologist with strong computer background for a data energets project in an environmental eclences project in an environmental eclences program. Some expendence in petroleum geology would be useful. The appointee will have the opportunity to be involved in a general geoscience research program. Salary and conditions of appointment will be commensusts with the qualifications of the appointmen.

Candidates should submit a curriou-ium vitas, including statement of re-search interests and the names of three professional references to: Mr. Bernard Menowitz, Chairman, Depart-ment of Energy & Environment, Brockhaven National Laboratory, As-sociated Universities, Inc., Upton, L.I., New York 11973, soe/mi

1) 1) Brookinsven Hallonal Laboratory Associated Universities fac.

Memphis State University/Faculty Position to Geophysics or Geomorphology/Remote Sensing. The
Department of Geology invites applications for an
anticipated tenure track position starting September
1988. Retides normal departmental duties, the successful candidate in geophysics will be expected to
cooperate with our active affiliate insultate, the Tennessee Earthquake Information Center (TEIC). The
department and TEIC want to augment their
strength in solid earth geophysics with an addition
in exploration geophysics. Preference will be given
to geomot phology candidates whose interests combine grommephology and tectonic processes.

Applicants should aubmit a letter or application,
resume and name/address/phone number of three
references to: Phili Deboo, Chaicman, Department
of Geology, Memphis State University, Memphis,
TN 88152.

Atmospheric Chemistry & Aeronomy Olvision (ACAD) and Belentific Computing Olvision (SCD)/ Ph.O. Scientist I or H. The National Center for Atmospheric Research in Boulder, CO is seeking a scientist to establish and manage the scientific research in Incoherent Statter Radar data base. Will interact with user and radar community to establish research project to insure appropriate scientific use of data base. Position tequirements include Ph.O. degree or equivalent, research experience in aeronomy physics, electronic engineering, atmospheric science, or closely related field. Familiarity with the Incoherent Scatter Radar techniques for measuring the properties of the ionosphere, magnetosphere, and atmosphere. Comonstrated high level of skills in savanced FORTRAN programming, numerical modeling data reduction techniques, tevel HII requires national scientific recognition and demonstrated leadership skills in and promoting furoherent Statter Radar research. This is a term position subject to annual review and continued funding for project. Sciul resume PROMPTLY to Enter Blazon, NCAR, P.O. Box 3000, Omilder, CO 80307 or call 303-194-5151 ext. 581 got information.

NCAR is an equal opportunity/affirmative action employer.

lowa State University of Science and Technology, Oepartment of Earth Sciences/Faculty Positions - Applications are invited for a tenusc-track faculty position in unineral renources. Rank is at the assurant or associate professor level, dependent upon qualifications. The successful applicant will be expected in develop a strong research and graduate student program in mineral tesources/economic geology and will teach undergraduate and graduate courses in this subject. An applied field orientation is preferred.

Towa State has enablished a Mining and Mineral Resources Research Institute in order to support and develop research and education in mineral resources. An interdepartmental graduate minor in Mineral Resources has also been enablished. In addi tion to the appointment in the Department of Earth Science, there will be buly opportunities to interact

Sciences, there will be bull opportunities to interact with three programs.

Completion of the Ph.D. prior to appointment is strongly preferred. In addition, rewarch ability shown by other public among analyst posterioral in industrial experiency will be an advantage. The position is currently available and becapacide to begin no later than September 1983, For application information, please write to:

Bent E. Nordlie, Unarrant
Department of Latth Sciences
253 Science 1

lowa State Currently

Ames, lowa 50011

Lowa State Charterity is an equal opportunity afformative action employer.

Research Positions Lunar and Planetary Laboratory. The Lunar and Planetary Laboratory at the University of Arizona ltat research positions open for Planetary Scientists, with Planetary Astronomy and Planetary Geology being areas of greatest interest to the Laboratory at this time. Retearchers at the Laboratory have access to the University's observatorics, a wide range of astronomiral instrumentation, a complete collection of planetary intages, computers and laboratory facilities. The research ranks in the Laboratory, namely Assistant Planetary Scientist, Associate Planetary Srientist, and Planetary Scientist, Associate Planetary Srientist, and Planetary Scientist parallel the tenure track ranks of Assistant, Associate and Full Professor. The Laboratory is interested in making appointments at the Assistant or Associate Planetary Scientist level. These are nut tenurable and not state-funded positions. Salary levels are commensurate with equivalent tenure-track ranks. Researchers in these positions will be expected to supply a significant portion of all of their salarles through their grants and contracts.

Applicants should submit a curriculum vita, list of publications, and the names of three references by April 90, 1983, to L. L. Wikkening, Director, Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona, 85721.

The University of Arizona is an equal opportunity, affirmative action employer.

Franklis and Marsball College/Petrologist. We have a 1-year position for the 1983-84 academic year with the possibility that the position may be extended for 1 additional year. The position is full-time involving up to 12 rontact hours/semester. Candidates woold teach petrology (a non-semester combined igneous and metamorphic course) and either economic geology or a course in their specialty. Candidates would also teach introductory physical geology once a year. Completion of Ph.D. prior to appointment is preferred but not essential.

Franklis and Marsball College has an active geology department which consists of 7 full-time staff members and graduates 25 majors per year. Teach-

members and graduates 25 majors per year. Teach-ing and research facilities are excellent including an automated XRF vacuum spectrometer. The college is a small (2000 students) four year liberal arts listi-

tution.
Candidates should send resume and arrange for 3 letters of reference and transcripts to be sent to: Dr. Similey A. Mertzman, Chairman Department of Geology.
Franklin and Marshall College P.O. Roa 3003
Lancaster, PA 17604.
Franklin and Marshall College is an equal opportunity employer.

Isotope Geologist/Uoiversity of Wyoming. The Department of Geology/Geophysics invites applications for a tenure track position at the assistant professor level in hotope geology. The applicant's lield of specialty may be stable or radiogenic isotopes. The successful candidate will be capected to teach undergraduale and graduate courses and conduct his/her own research brogram.

Current research at the University of Wyoming includes: crustal evolution in the Archeun and Proterozoic; the systematics of magina contamination; carbonate diagenesis; field-rock interaction; and the tectonic evolution of compressional and extensional orogenic belis. We hope the successful candidate will complement these studies as well as develop a strong, independent program. Applicants should submit a vita, transcripts, a letter describing future research intorests, and names of three references to Dr. Robert S. Houston, Head, Dept. of Geology Geophysics, PO Box 3006, University Station, University of Wyoming; Laramie, WY 82071. Closing date for applications is Pebruary 28, 1983; The University of Wyoming is an equal opportunity/affirmative action employer.

### AMOCO Foundation Ph.D. Fellowship

Department of Geology University of Missouri-Columbia

The Department of Geology invites applications for the Amoco Foundation Fellowship to support an outstanding Ph.D. Candidate in any subdiscipline of geology. This 3-year fellowship includes a generous stipend, walver of tuition and lees, and substantial funding to support research. The Department of Geology has dynamic research programs in sedimentology, sedimentary petrology, low temperature geochemistry, tectonics, geophysics, paleontology, and igneous and metamorphic petrolo-

For application materials and additional information contact:

Director of Graduate Studies Department of Geology University of Misaouri-Columbia Columbia, MO 65211 The deadline for application is Morch 1, 1983.

Assistant or Associate Professor/CSM. The Geology Department of the Colorado School of Mines ingy Department of the Colorado School of Mines invites applications for a faculty position commencing September 1, 1983 as Assistant or Associate Professor of Geology in the specialty of Paleoutsdogy and Sedimentary Geology to teach courses at the undergraduate and graduate levels, direct theses and not-dust research in these areas. The Ph.D. degree is respitted. Salary is dependent upon experience.

The dearline for applications in April 15, 1983.
Resumes and references should be mailed to: Dr. J. J. Finney; Hearl, Geology Department: Colorado School of Mines; Golden, Culorado 80401.

Colorado School of Mines is an Affirmative Action, Equal Opportunity Employer.

### Vincent C. Kelley and Leon T. Silver **Graduate Fellowships**

DEPARTMENT OF GEOLOGY THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the Univarsity of New Mexico invitaa applicetions for the Vincent C. Kelley and Leon T. Silver Graduele Fellow ehips. The fellowehips will be awarded on the basis of the achoi eslic record end academic promise o graduata applicents. Each tellowahl will provide for a generous living ell pand of \$1,000/month for 9 to 12 montha, and up to \$2.000/year fo treval end research expenses. The Caswall Bilvar Foundation will pay all fullion and university tees. The awsrda are mada on an ennuel baels. but may be renewed for up to three years for those individuels in the masters program, end up to live yaers to those individuels complating both M.S. and Ph.D. degrae requirements A M.S. Iheels may be used as a basis for Ph.D. program. Preference will be given to; but is not restricted to applicants for the Ph.D. progrem.

An application for admission to the Graduete Record Exam results (verbel, main and geology), three letters of reference end e brief elalement of research goals at a required for con-alderation for the fallowships. Ap-plication materials may be obtained

Rodney C, Ewing Department of Gaology University of New Mexico Albuquerqua, New Mexico 87131



The deadline for englications is: tarch 1, 1983 for the Fell semester of 1983.